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December 1, 1927

Closing Mound Landing Crevasse

Second of a Series of Articles on the Mississippi Flood Area

Hydrogen-Ion Control of Sewage Sludge

European River-and-Harbor Laboratories Revisited

Long-Time Tests on Concrete Using Various Coarse Aggregates

Production and Profits on Road Work

Reconstruction of High Bridge, Croton Aqueduct

Taking Down Stone Arches of High Bridge Over Harlem River at New York

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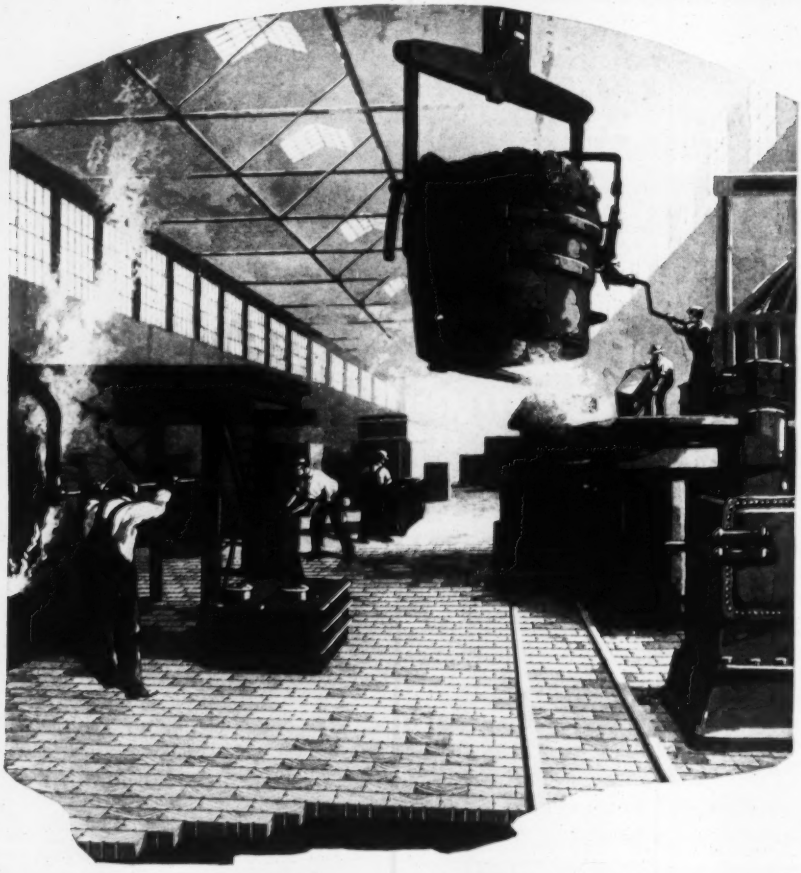

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DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

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Lake Michigan Diversion

WITH a half dozen states on each side of the lawsuit before the U. S. Supreme Court on the diversion of waters from Lake Michigan through the Chicago Drainage Canal to the Mississippi River system, and with sanitation, navigation and hydro-electric power concerned, the findings of Charles E. Hughes in his report as special master, abstracted in our news section this week, have far more than local interest. If the recommendations of the report are followed, the supreme control of Congress over navigable waters, whether exercised by itself or by delegation to the War Department and thus to the Chief of Engineers and his staff, will be established on a much broader and firmer basis than ever before. There will be left to the discretion of Congress, as a matter of "national policy," to use Mr. Hughes' term, the diversion of water from one drainage basin to that of another, even to the detriment of the former for the benefit of the latter. The opinion is a "victory" for Chicago, but with a sting. It holds that Congress or the Secretary of War has as much right to revoke or modify as to grant the permit. It supports, in general, the army engineers' attitude that the permit is, at least in large measure, a temporary expedient to meet a condition that can and should be remedied, and supports the permit conditions as to construction of sewage and water treatment works and metering the water supply of Chicago. Happily, the Sanitary District is proceeding diligently with sewage-works and Chicago is making water purification studies. Unhappily, Chicago, after starting a metering program, has balked. Perhaps these findings, if adopted by the court, will help force it full speed ahead.

Hydraulic Research

AN interesting picture of hydraulic research is sketched by John R. Freeman in his account of a visit to European river-and-harbor laboratories. Large money savings are being realized through the work of these institutions, he says. Since there are no similar laboratories in this country, the inference suggests itself that we are not attaining the efficiency or economy in our harbor, river and hydraulic work which might be had with their aid. Obviously this is a debatable inference, and especially in view of the extraordinary difficulty of reproducing in miniature the working conditions of coast, bar, inlet or channel a skeptical attitude toward this type of research may seem natural. But there is too ample proof of the value of research in every field of modern technical activity to permit such skepticism to be maintained. The fact is, our lack of river-and-harbor laboratories is not deliberate choice but, rather, mere failure of initiative. Private engineers, who do very little of the actual work in this field, have no incentive to research, and government agencies have usually not thought such research worth while or practicable. The Bureau of Reclamation has done some valuable investigative work on hydraulic problems, but we recall none in the field of rivers and harbors, which is in charge of the Corps of Engineers of the army. Meanwhile our need for better technique is increasing rapidly as country and population grow. Even at present the loss in value in land eroded by streams each year would probably cover the cost of many laboratories. The near future may see a marked change in attitude toward such research institutions.

The Crosstown Problem

AMONG municipal operating troubles the competition of intersecting traffic streams rises up as an evermore bothersome one. Its most common form in the case of urban traffic is the conflict of a major stream with intersecting minor streams, which for brevity may be called the problem of crosstown traffic. It is found in the rural town as well as in the metropolis; in neither has it yet found a satisfactory solution. Under present conditions bad results of two opposite kinds can be observed. In some instances the major traffic obtains so large a predominance over the competing transverse traffic as to reduce the ease of crosstown flow most seriously; a prominent effect is to depress values away from the longitudinal traffic arteries and thereby intensify the central congestion, which, in turn, causes the traffic problem to build up geometrically. In other instances, especially where automatic signaling is depended on, the tranverse traffic obtains virtually equal rights with the longitudinal, and the main traffic is thus delayed and blocked. In both instances, large time intervals of the interlocking aggravate the resulting troubles, and current practice in this matter of time interval still exhibits great and apparently unreasonable variations. There is occasion for much study of these ultra-modern conditions of life before the best adjustment of operating methods is reached. But we are confident that engineering method will in time find suitable solutions of the crosstown problem.

A Notable Reconstruction

THE history of the Roman-type masonry aqueduct, High Bridge, has been so closely allied with that of New York City and its old Croton water system for the past 75 years that, when its reconstruction or removal became necessary, plans and protests from every quarter were received. Its reconstruction, as described elsewhere in this issue, is noteworthy in two main particulars. It shows that for sentimental and esthetic reasons alone, so commercial a city as New York will pay nearly $1,200,000 to retain a structure that originally cost about $965,000. It is also noteworthy because of the design of the reconstruction and the working methods applied by the contractor. Required to substitute a steel arch for five of the

existing masonry arches, the contractor worked out a plan of co-ordination in which the falsework and erection traveler for the steel arch could be used for the demolition work. Ordinary procedure was complicated by the necessity for maintaining traffic on a boulevard, several lines of railway track and on the river. Conversion of an ordinary pier, whose foundation conditions were practically unknown, into an abutment to carry one end of a 426-ft. steel arch, and adaptation of a method to hold the remaining part of the structure after the river arches had been broken and before the steel arch was in place, were major problems. All these preliminaries to the erection of the new arch attest to the fact that reconstruction often taxes the engineer's designing powers and the contractor's ability even more than does the new work.

A King's Ransom

IT has been quite generally known that industrial concerns were devoting large sums of money to research. Nevertheless it comes as a surprise to learn from a report of the National Industrial Conference Board that this expenditure amounts to the huge total of $200,000,000 annually—a king's ransom, or the ransom of many kings! Translated into terms of research personnel, equipment and supplies the figure appears fabulous. One may suspect that it covers many activities more properly classed under the headings of development and promotion work, for with the popularization of the term research its scope has progressively been widened, even to the extent of including such inquiries as the recent one on the subject of instalment buying. With every allowance of this kind, however, it is plain that American industry is thoroughly committed to the doctrine of creative study and is financing it on a grand scale. In five years the number of corporations which maintain research departments or laboratories has doubled, to a present total well over a thousand. And it is to be noted that this movement has grown spontaneously, without governmental prodding or coddling. For this reason it is of live promise, reminding of the virility and success of German chemical research through many years, as contrasted with the slender productivity of the government-stimulated research carried on in England since the war. If publicists and orators have before now paid homage to the growth of American industrial research, their encomiums will bear iteration and further emphasis in the light of the actual statistics. Our industrial technology will be secure against all rivalry so long as research occupies thus exalted a place in industry's budget.

Permanency in Buildings

STRUCTURES with a life many times longer than we are accustomed to regard as permanent are discussed in the article in this issue on "Modern Pyramids." Although the article deals primarily with our ability to duplicate or excel the ancients in the building of eternal monuments, and to this extent is academic—since we moderns appear to have no desire to build such works—it contains usable lessons for our more ordinary building operations. In connection with these, it registers both satisfaction and doubt in the progress being made in the technique of design and construction toward the goal of more permanent structures. Satisfaction is, for the most part, based on increased knowledge of stress analysis and determination, and on greater proficiency of erection technique by virtue of modern equipment; we now build more surely and more safely. Doubt, on the other hand, lies largely in the field of materials. Now, as then, the list of imperishable materials is short, and, strangely enough, practically unchanged—granite, limestone and marble, bronze and lead. Either by omission or by qualified inclusion, our more modern materials, represented by steel, portland cement and reinforced concrete, are stamped with doubt. In particular, steel framework protected by concrete encasement is the most surprising omission. To what degree are these modern materials really subject to this doubt as to their imperishability? When used correctly, what is their present length of life? What is being done or can be done to make them more permanent? All these are questions which need answering. Perhaps really permanent structures are not desirable, but certainly a longer existence than many modern structures enjoy is one of the most important problems of civil engineering and construction today. Whether or not the author meant it so, his article contains a challenge for the partisans of some of the more modern materials that have evolved since the stone age.

Road Construction Studies

EFFICIENCY studies of concrete roadbuilding methods have progressed greatly in the last two years. Engineers, and particularly contractors, are now giving the same attention to economical production of concrete roads as has previously been given to economical design and to pavement structure. The new problem has a greater number of human variables and so the values being arrived at are not so nearly absolute. Because of this, these studies to fix values have perhaps too often been criticised by the practical roadbuilder as theoretical and academic. At times, it must be confessed, they have had just these characteristics. They have borne too heavily on the stop-watch and the comptometer as true indices of management efficiency. They have considered too little the vagaries of human performance and the uncertainties of nature as influences on well ordered sequences of operations. Yet they have possessed great value. They have encouraged the ambition to study and have formulated procedures of investigation. These statements are especially true of the studies of the Bureau of Public Roads under the immediate direction of J. L. Harrison, whose discussion of the relation of profits to production is published in this issue. It is in emphasizing such relationships that the amassing of stop-watch and other counts has value. It may be often the case that absolute values arrived at are untrue but it is rarely the case that general relationships of cause and effect are not truly indicated. Herein, as every contractor who has kept them knows, lies the fundamental usefulness of performance records and cost data and counts of many kinds. The absolute values can seldom be applied to the specific operation being considered but the relationships established by sufficient counts are general and fundamental. It is in this spirit that highway builders are urged to appraise the economic studies of road construction methods which have been so widely undertaken by the Bureau of Public Roads engineers and others who are putting stress on the methods of full and precise counts.

The Golden Gate Bridge

FOR five years or more private interests have been proposing a bridge across the Golden Gate at San Francisco. This scheme, which is not to be confused with the proposal for a transbay bridge between San Francisco and Oakland, is now being aired in a series of court hearings held to determine a legal phase of the matter. A report on the project presented at the first of these hearings by three well-known engineers is abstracted elsewhere in this issue. A bridge across the Golden Gate of the sort proposed would require a span exceeding 4,000 ft. between supports and would involve two towers almost as high as the Eiffel tower. This span would be much more than double the length of any thus far built and the towers would also be without precedent. While the Eiffel tower has widely spread footings and is a light structure carrying no load at its top, the Golden Gate bridge towers would of necessity have a relatively narrow base and would have to sustain an enormous top load. The live load in such a structure is almost insignificant when compared to the enormous dead load, and hence the members necessary to support the structure itself would be of very great size. Without going farther into detail it is apparent that any such bridge would require the solution of many new problems and it would be most unwise to attempt to finance it until the working out of these problems had progressed far enough to give some adequate idea of probable cost and hence the feasibility of the project.

It is natural, therefore, that such a bridge scheme, unsupported by data about the various problems involved, should be opposed by the engineers of San Francisco. This opposition is the stronger because the present scheme for a Golden Gate bridge is accompanied by a total cost estimate considered far too low—but little more than one-quarter what a competent board of engineers has estimated as the minimum probable cost. In other words, despite the uncertainties, the new problems to be solved and the inevitably greater cost of pioneering in a field where there is no precedent, proponents have placed the total cost of this structure at less than the cost of the Philadelphia-Camden bridge although that bridge has a span of only 1,750 ft. and occupies a much more favorable site than the Golden Gate.

No competent engineer has said that the Golden Gate cannot be bridged; it undoubtedly can and probably will be bridged in time unless the advance of aerial transportation offers a preferable alternative. However, it is a far cry from that which is possible, regardless of cost, to that which is feasible from the financial viewpoint. Californians attach much sentiment to the strait to which they have given the attractive name of "Golden Gate." The location is conspicuous, scenic and strategic: It is a highly important point in history, in commerce, in national defense and as a feature of the beautiful setting with which Nature has endowed San Francisco. To launch an engineering project for bridging this strait and then, with the work but partly done, to meet financial difficulties and years of delay, would be a great misfortune to the engineering profession and a mortification to the proud Golden State.

Maintaining a good reputation for the engineering profession requires that the financial side of great engineering projects be kept on a sound basis. This makes all such great ventures of interest to the profession at large. Californians who would keep the Golden Gate profile free of a partially completed and abandoned structure, and taxpayers who would be assessed to finance the venture, will also agree that no Golden Gate bridge project should be launched until there is assurance from the most competent and experienced engineers that the project has been studied in detail and is proved to be feasible; that it has been so planned and financed as to assure its completion within a reasonable time; and that its total cost will be within a reasonable amount, not out of all proportion to the service the bridge is to render or to the revenue it may be expected to return. No scheme for bridging the Golden Gate that meets all or any of these three requirements has yet been proposed.

Riverbank Emergencies

RESIDENTS of the Mississippi basins who live constantly under shelter of the levees will have no difficulty in understanding the driving haste that was put into the Mound Landing work described in W. W. DeBerard's terse recital in this issue. To them it will seem natural that as fast as possible a bank of earth should be piled up to keep out the river in the next high-water season. Engineers who live far from the Mississippi are more likely to be impressed with the contrast between this high-speed levee building and the painstaking practices followed in constructing earth dams for reservoirs. The discriminating selection of materials and care in placing which characterize the latter type of operation are strikingly absent from the work on the levees.

In the present instance, emergency conditions made the time factor controlling; but even in ordinary cases of Mississippi levee building, the process is not far different. Soil must be used as it is found in the immediate vicinity, and the structure must be adapted to a weak and often porous foundation. If dam builders should question whether the resulting levee can be secure, the answer is that in long and severe experience the type has proven itself dependable by the fact of only a very small record of failure. Even with its easily saturated soil, the old levee at Mound Landing held against the flood until an overtopping stage had been reached—only then did the saturation begin to melt down the back of the levee.

Yet Mr. DeBerard's narrative will help to explain why the great complex of technical questions about Mississippi River protection raised by the 1927 flood includes the possibility of improved levee sections, better safeguards in design, and more substantial construction. The attacking forces are many, and include not only leakage and saturation but also underflow and bank erosion. The two former hazards have generally been least important, which again is a fair defense of the methods described. Scour —both high-water and low-water—has found no other solution so far than the slow and costly application of a perishable form of revetment. In the matter of underflow, the levee remains at the mercy of the unknown but nearly always undependable subsoil.

In every aspect, then, levee protection has the character of emergency work and constitutes a formidable problem of due balance between careful construction on the one hand and speed and economy on the other. But the present is pre-eminently a time for exhaustive restudy of levee construction methods. It may be hoped that the Mississippi River report which the Chief of Engineers is soon to render will include the full results of such restudy.

Reconstructing Croton Aqueduct High Bridge

Five of the Masonry Arch Spans Being Replaced by Single Steel Arch to Preserve Historic Aqueduct of New York City's Old Croton Water System

HIGH BRIDGE, New York City's Roman-type masonry arch aqueduct, is being reconstructed in the interests of navigation. The Harlem River, which it spans, is included in the War Department's plan to provide a channel, at least 15 ft. deep, entirely around Manhattan Island; and four of the piers of the monumental and historic 15-arched structure were located in the planned channel.

The problems incident to the reconstruction are numerous. The main design problem, other than that and on eight railroad tracks passing beneath the structure. A general plan of procedure in meeting these problems was worked out in advance leaving the details to be developed as work progresses. This plan is satisfactory.

Description of Bridge—High Bridge was begun in 1839 and completed in 1848 to carry the old Croton aqueduct across the valley of the Harlem River from what is now Bronx borough to Manhattan, near 174th St. There was at first a low bridge across the river, and when, in 1839, the legislature directed the construction

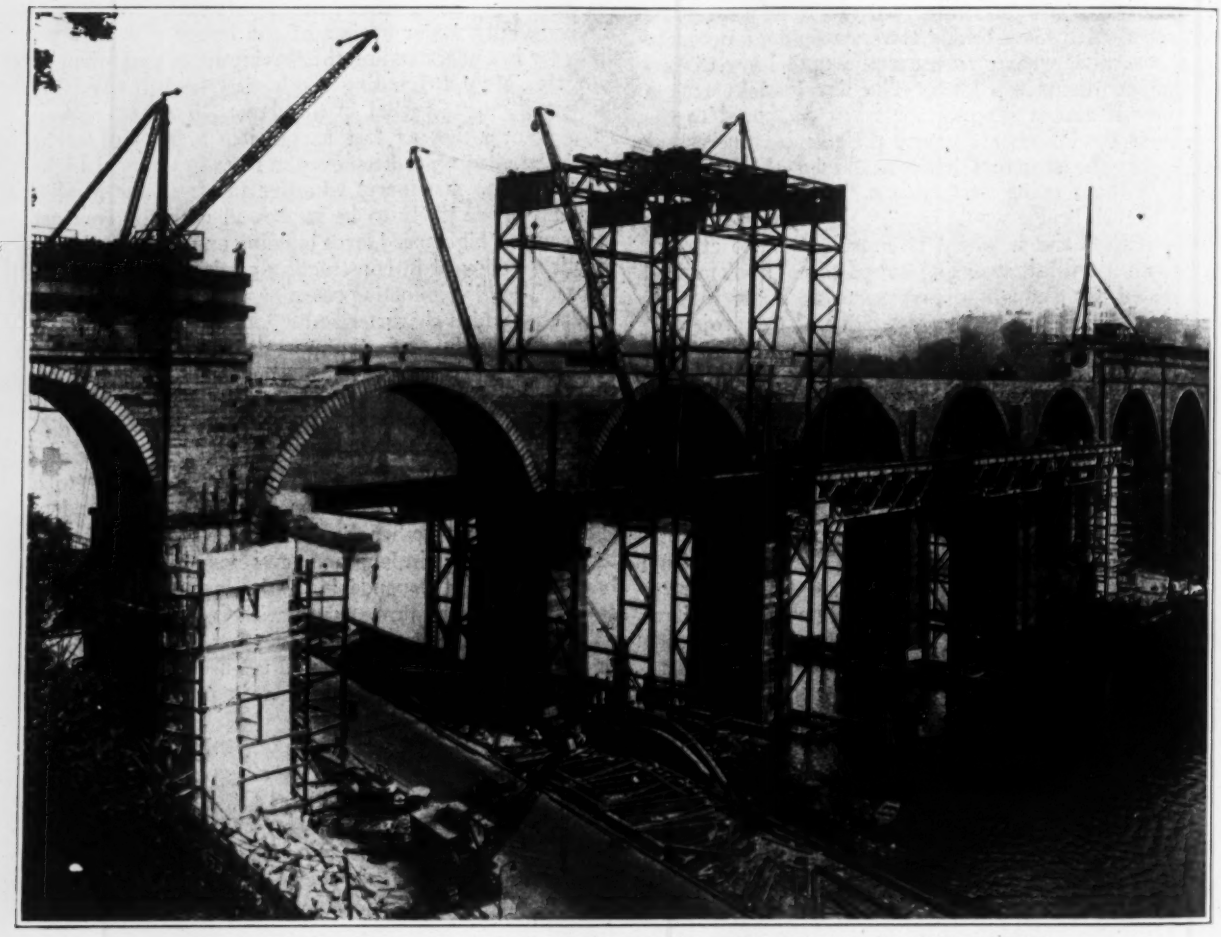


FIG. 1—CONTRACTOR'S PLANT AND OPERATIONS, HIGH BRIDGE RECONSTRUCTION
Gantry used both for demolition and for steel arch erection. Wooden centering being placed for removing arch barrels. Harlem River driveway and reinforcement work on west abutment pier, in foreground.

of a new structural steel arch, has been the conversion of two of the old masonry piers into abutments of sufficient size to carry the new arch. From a construction procedure standpoint, there were the problems (1) of replacing the aqueduct in service as soon as possible necessitating close co-ordination of the masonry demolition and the steel erection work, (2) of holding the old masonry piers after the arches to be removed had been broken, and before the steel arch was in place, (3) of building a tight cofferdam in swift river current, and (4) of maintaining traffic on the river, on a boulevard of a high bridge in its place, the latter name attached itself permanently to the structure, and the official name of Aqueduct Bridge has all but been forgotten.

The structure is one of the outstanding examples of Roman architecture in the United States. Its 15 arch spans of granite have a total length of 1,197 ft. over abutments, as shown in Fig. 2, which also indicates the general reconstruction plan. The bridge consists of six 50-ft. arches on the Bronx shore, eight 80-ft. arches as the original river spans, now reduced to five by filling operations, and one 50-ft. arch on the Manhattan shore.

Supported on these arches is an attic story housing the aqueduct, which consists of two 36-in. diameter cast-iron pipes laid about 1848 and one 90½-in. wrought-iron pipe laid about 1864. In the reconstruction, only the wrought-iron pipe will be retained. The roof of the bridge, which has been used as a promenade walk, is 21 ft. wide under the coping, and about 121 ft. above M.H.W. The arches have a clearance of 100 ft. above M.H.W. in the Harlem River.

All masonry is of cellular granite construction excepting the attic roof and the interior or insulating walls, which are of brick. Rosendale natural cement was used in the construction, and where it was not exposed to the weather was found in excellent condition. Interior granite masonry above the arch barrels includes haunch backing, longitudinal distributing walls, and the backing of the spandrel walls. The spandrel walls are buttressed by pilasters on the up and downstream faces of the piers, and additional rigidity is provided by stone struts between the spandrel and the haunch walls (Fig. 3, Sec. B-B). The new abutment piers and the approaches are founded on rock, as are piers 1, 6, 8, 9, 10 and 14. The other piers, including the four to be removed, are supported on piles.

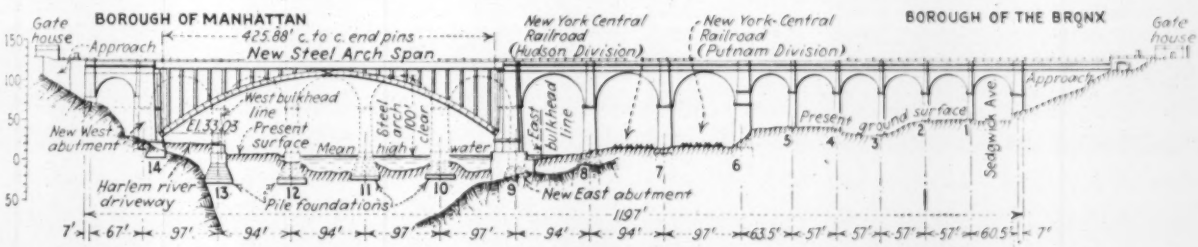


FIG. 2—RECONSTRUCTION PLAN OF AQUEDUCT HIGH BRIDGE, NEW YORK CITY
Part of old structure, affected by reconstruction, shown dotted.

Reconstruction Plans—In 1920 the War Department ruled that the existing bridge was an obstruction to the free navigation of the river on account of insufficient clearance between piers, and proposed that two alternate piers be removed, providing two widened spans with a vertical clearance of at least 100 ft. above M.H.W. Another plan, later proposed, was to remove the bridge, and to re-erect it as a monument over Dyckman valley at 200th St. and the Hudson River on the prolongation of Riverside Drive. From historical and artistic standpoints, it was desired to keep the bridge in its existing location, however, and the final plan prepared by the city and approved by the War Department is to remove the four channel piers, substituting therefor a steel arch with satisfactory navigation clearances. This arch is to be of three-hinged plate-girder type, 426 ft. between end pins.

Plans for the method of reconstruction also have gone through various changes. The reconstruction plan upon which bids were first invited provided for keeping the aqueduct in service during the work. It contemplated first erecting the new steel span, and then dismantling the old masonry spans, employing the old spans as supports for the new during its erection, and the new as supports for the old in dismantling. The attic story was to be removed, and the permanent floorbeams of the steel arch inserted beneath the aqueduct, resting on the masonry floor. Spandrel columns hung from these beams would then suspend segments of the steel arch until it was swung. This procedure required the use of a steel span wider than the old bridge, and bids finally were received on a structure 35 ft. wide. However, the lowest bid exceeded the money available, and the bids were rejected. Next, the plans were modified by eliminating the requirement that water service should be maintained continuously. This permitted a reduction in width of the new steel arch to the same width as the old structure, with the result that the lowest bid was $1,190,300. Incidentally, the total cost of the structure as completed in 1848 was $963,400.

Briefly, the procedure being followed is to remove in sequence the attic story, all of the aqueduct pipes and the arch barrels, and the river piers; to reinforce the abutment piers during these operations; and then to erect the steel arch on falsework.

The New Abutments—Much of the difficult part of construction centered around the new abutments, especially in the matter of enlarging the under-water portion of pier 9 to adequate size. Because of uncertainty as to the foundation conditions of this old pier, it was necessary to examine it, and to do all reinforcement work in the dry. A cofferdam 55x70 ft. and 33 ft. deep, with double walls 10 ft. apart, was built of 14-in. arch-web steel sheetpiling driven around the old pier. This work was made more difficult by the tidal currents, which at times ran 7 m.p.h. Watertightness was secured by filling between the double walls with clay puddle. The specifications required that none of the bracing be left in the concrete, and the consequent removal of the heavy timbers added another difficulty. During the work, the old oak cofferdam, used in building the original pier, was uncovered intact and in excellent condition.

Above the water line the abutments are reinforced on the up and downstream and river sides with granite and concrete backing around the old shaft. The concrete backing provides the anchorage for steel shear bars passing through both the new and the old masonry into the cells of the old piers, which also have been filled with concrete. Above the springline of the arches, the pier pilasters are tied together transversely by 2-in. bars 30 ft. long. As additional aids to the rigidity of this part of the old structure, both permanently and during the construction period, a concrete diaphragm was placed in the attic as shown in Fig. 4, and concrete filling was placed between the longitudinal walls.

The crux of the reconstruction plan was to provide a means of holding the old portion of the bridge after the river arches had been broken, and before the steel span was swung. The specifications gave the contractor the option of submitting his own plan of operations, and this plan, as submitted and approved, was to build the new abutment piers as high as possible and to full cross-section, thus providing true abutment piers for the remaining arches of the old bridge before any unbalanced thrust was brought into play by breaking the river arches.

Following this, the river piers could be removed and the steel arch erected.

Dismantling Work—Replacement of the aqueduct in service in minimum time was a prime necessity. It was, therefore, necessary that the dismantling and steel arch erection work be co-ordinated in the best possible manner. The contractor based his study of plant layout for the work on two requirements—(1) that the least possible additional loading, due to plant, should be imposed upon the bridge, and (2) that the plant should be capable of being used for dismantling the masonry arches and piers to high-water level, and later for providing falsework and plant for the erection of the new steel arch. Various combinations of track and cars, cableways, traveling derricks and elevators were planned and studied. Several designs of gantry runways and travelers of timber construction were prepared, and the bid was based on this type of plant. The subcontractor for the steel later submitted a similar design for a gantry traveler and runways of steel construction. This design was adopted and the plant is now in operation removing the old masonry. When the masonry is removed to high water, the subcontractor will take over the gantry and erect the steel arch.

The steel runways have been designed to avoid interference with river and boulevard traffic. They consist of steel tower bents on both sides, outside each river pier, supporting longitudinal trusses with lower chords 60 ft. clear above M.H.W. These trusses support the track for the electrically operated traveler, which spans the structure transversely. The steel bents are supported on I-beams spanning between pile clusters in the river and chased seats in the old piers.

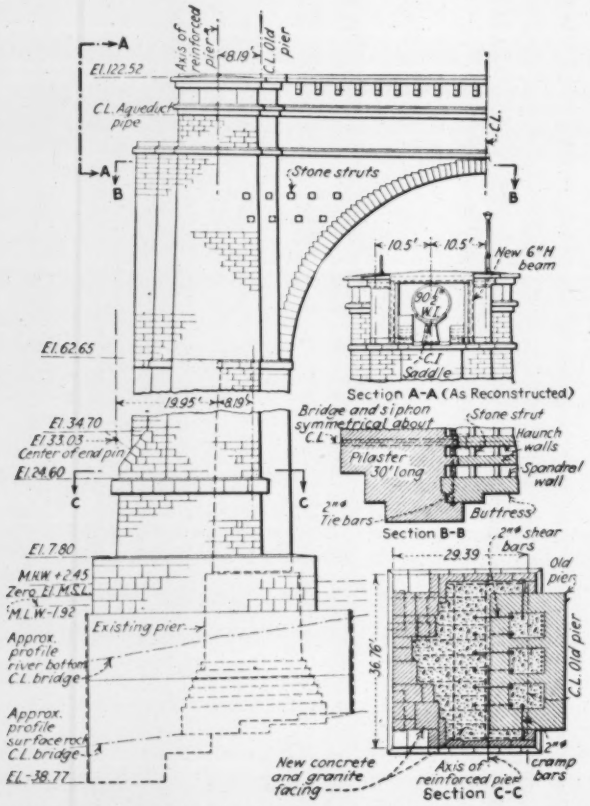


FIG. 3—RECONSTRUCTED EAST ABUTMENT FOR THE STEEL ARCH

Old Pier shown dotted.

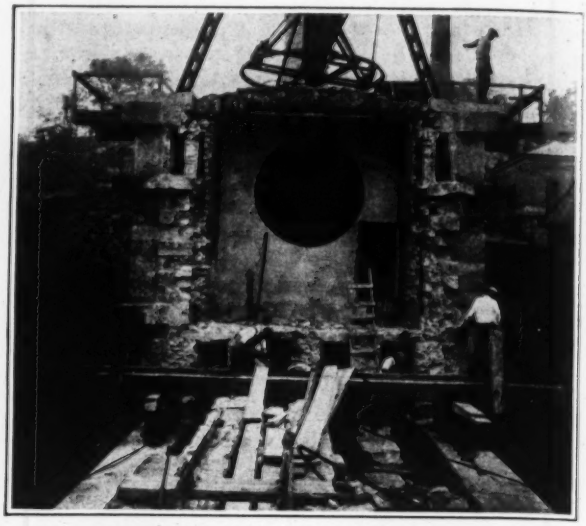


FIG. 4—THE AQUEDUCT AT THE TOP OF THE WEST ABUTMENT PIER DURING DISMANTLING

Note concrete diaphragm placed in attic for rigidity; spaces between longitudinal walls also were later filled with concrete.

In addition to the gantry traveler, stiff-leg derricks have been erected on top of piers 9 and 14, while along the top of the haunch walls has been laid an industrial track, on which operate cars equipped with hand hoists for handling the smaller stones. Thus, the old masonry can be lowered by the gantry traveler direct to barges in the river or can be transported to either abutment pier and lowered to motor trucks. The attic story and all masonry above high-water line are being removed by barring and wedging, and by the use of paving breakers. The underwater masonry, down to El. —20, will be blasted and removed with a dipper dredge.

In the dismantling operations, extreme care is exercised not to introduce unsymmetrical loading on the arches and piers. The longitudinal walls and the pilasters are being taken down in stages, each corresponding to the height between the stone struts, so that at no time are any of the walls on the arches or piers left standing without lateral support for a height greater than the height between the struts. The haunch backing on each masonry arch half-span is next removed to the height of the haunch backing carried over the piers. Then, before unkeying the arch barrels, wooden arch centering is erected. This arch centering is in the form of a truss with end supports on chased niches at the spring lines of the piers. As soon as the arches are broken and removed, the dismantling of the piers themselves will be carried to water level. The steel contractor then will commence the erection of the new arch.

Administration—The reconstruction work was planned and is being carried out by the engineers of the Department of Plant & Structures under the general direction of Edward A. Byrne, chief engineer. The general contractor is the P. T. Cox Contracting Co., Inc., New York City, P. T. Cox, president, and R. W. Briggs, chief engineer. John R. Flick is superintendent and Harold W. Knox is field engineer for the contractor. The McClintic-Marshall Co., New York City, is furnishing and erecting the steelwork under a subcontract with the general contractor.

Rigid-Frame Solid-Section Design Applied to Skew Bridges

Three-Dimensional Analysis Applied to Stress Determination—Costs of Rigid Frame and Other Types Compared

By Arthur G. Hayden
Designing Engineer, Westchester County Park Commission, Bronxville, N. Y.

THREE PIONEER bridges, of rigid-frame, solid-section construction similar to that described in previous numbers of *Engineering News-Record*, but heavily skewed, and with the effect of the skew calculated in the design, are being constructed by the Westchester County Park Commission to eliminate grade crossings between existing highways and the Westchester County parkways. These structures are the Fenimore Road bridge over the Bronx River Parkway at Scarsdale, N. Y., the Wilmont Road bridge over the Hutchinson River Parkway at New Rochelle, and the Old Mamaroneck Road bridge over the Hutchinson River Parkway at Scarsdale. Fenimore Road bridge is practically completed, and is carrying full load. The principal dimensions of these bridges are given in Table I.

TABLE I—PRINCIPAL DIMENSIONS OF NEW SKEW BRIDGES, WESTCHESTER COUNTY PARKWAYS

	Square Span, Ft.	Skew Span	Skew Angle	Clear Width, Ft.	Under-Clearance, Ft. Curb	Under-Clearance, Ft. Mid-Span
Fenimore Road Bridge	42	64 ft.	50 deg.	44	11	15
Wilmot Road Bridge	56	61 ft. 1 in.	22 deg. 32 min.	48	11	15
Old Mamaroneck Road Bridge	56	66 ft. 6 in.	31 deg. 51 min.	48	11	15

In an article in *Engineering News-Record*, April 29, 1926, p. 686, it was stated that the ribbed frame (that is, a structure consisting of a number of longitudinal rigid-frame girders supporting a floor slab) was preferable to the solid-section frame for a skewed bridge, on account of the greater uncertainty of action of the latter. Although some effects of skew exist and are accounted for in the ribbed structure, it was felt that other effects, not then calculable, were minimized by the ribbed construction. The facts that considerable uncertainty remained, that the ribbed construction involved more expensive formwork than the solid-section construction, and that the greater girder depth of the ribbed frame necessitated higher and longer approaches, with consequent loss of economy, led the designers of the commission to attempt an improvement of conditions.

TABLE II—COST ESTIMATES FOR SINGLE-SPAN BRIDGES OF VARIOUS TYPES

Clear width 40 ft. Clear span 64 ft. Underclearance: steel grider, 13 ft.; rigid frame, 11 ft. at curb, 15 ft. at center.

	Main Structure	Approaches	Total
Reinforced-concrete solid frame bridge	$19,000	$26,500	$45,500
Steel girder bridge	21,800	33,100	54,900
Reinforced-concrete fixed arch bridge	25,900	30,500	56,400
Reinforced-concrete ribbed frame bridge	17,700	37,400	55,100

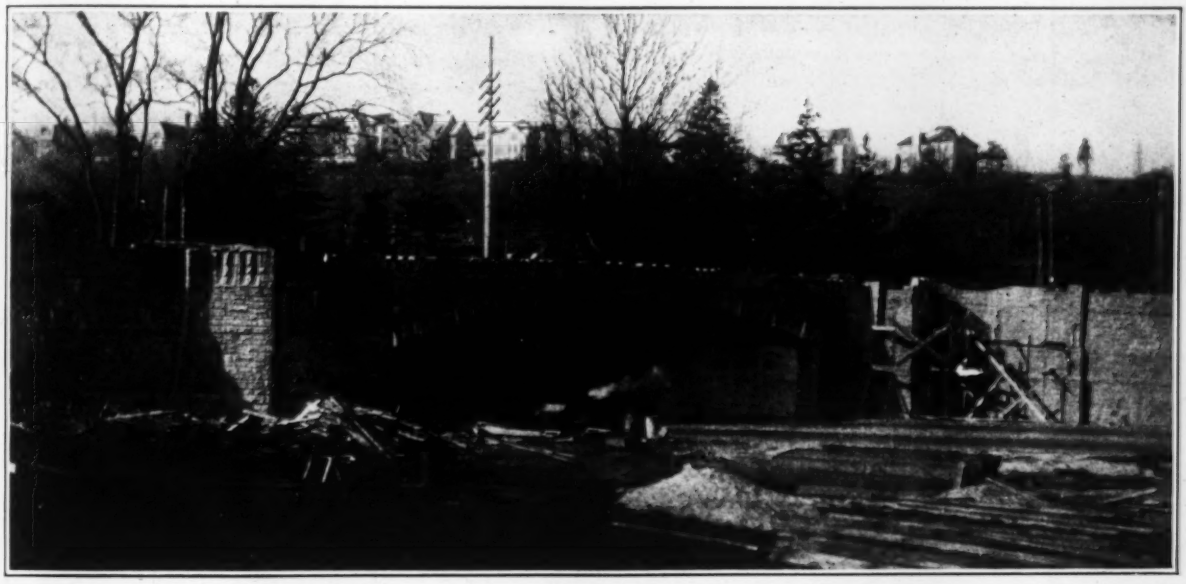


FIG. 1—FENIMORE ROAD BRIDGE OVER BRONX RIVER PARKWAY
A rigid-frame solid-section skew crossing designed with the help of mechanical analysis.

When the plans and estimates for the Fenimore Road bridge, as a ribbed frame, were completed in October, 1926, the imperfection of the ribbed type was particularly evident because of the unusual limitations imposed by street and parkway grades. Moreover, the heavy skew (50 deg.) accentuated the shortcomings of the ribbed construction from an architectural point of view, while precluding the design of a solid-section frame unless a rational analysis could be made.

Following Prof. J. Charles Rathbun's paper on the fixed skew arch appearing in the 1924 *Transactions*, Am. Soc. C. E., and the verification of his analysis by Prof. George E. Beggs of Princeton, by means of his three-dimensional deformeter tests, the writer interviewed Prof. Rathbun in regard to developing a like method of analysis for the two-hinged arch that would also be applicable to the skewed single-span solid-section rigid frame. The construction of the Fenimore Road bridge was delayed pending the results of his investiga-

tion. Prof. Rathbun's work was finished in December, 1926, and his method was applied to the design of the three bridges described in this article.

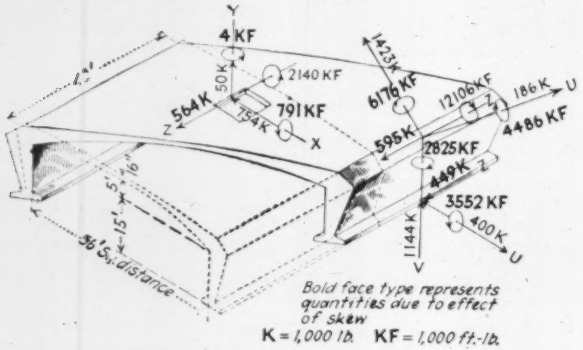


FIG. 2—DIAGRAM OF PRINCIPAL FORCES ON 33-DEG. SKEW RIGID-FRAME BRIDGE
Note that forces due to skew are resolved in 3 planes.

The new plans and estimates for the Fenimore Road bridge gave a direct comparison of ribbed and solid-section construction, which showed that a saving of

in structural design. However, some general observations may be made.

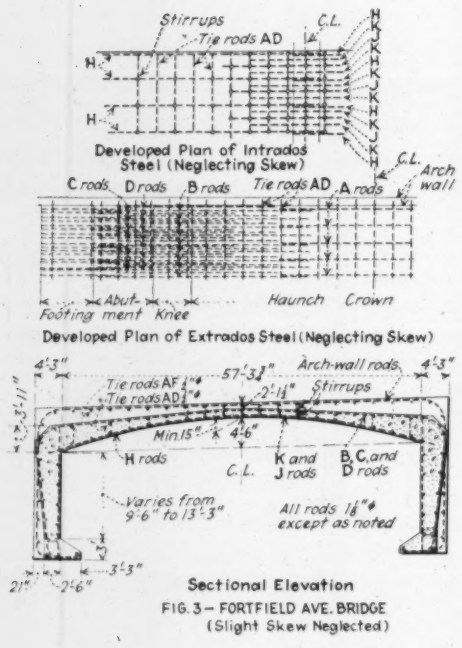
The skew frame is a statically indeterminate structure containing forces and moments which in general cannot be made parallel to a single plane, as in the case of the right frame. It must, therefore, be analyzed in three dimensions instead of two. A comparison of the two

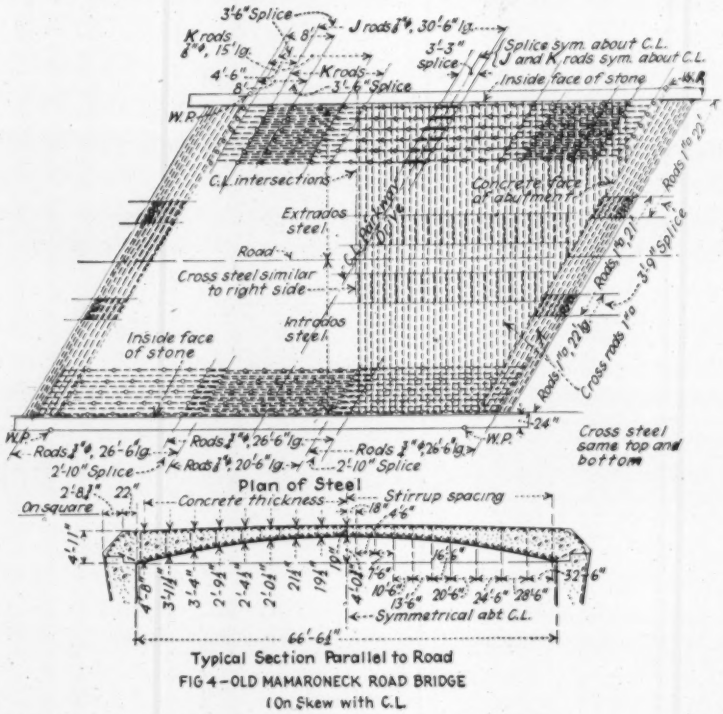
TABLE III—COMPARATIVE COSTS, STEEL GIRDER AND STEEL FRAME RIB CONSTRUCTION

Costs are for entire project.

Clear Width, Ft.	Clear Span, Ft.	Clearance Over R.R., Ft.	Steel-Girder Construction: Main Structures	Steel-Girder Construction: Approaches	Steel-Girder Construction: Total	Steel-Frame Construction: Main Structures	Steel-Frame Construction: Approaches	Steel-Frame Construction: Total
46	100	18	$65,000	$75,000	$140,000	$45,000	$75,000	$120,000

cases is given in Fig. 2, which shows the principal forces existing at the crown, at the knee and at the footing of the frame of the Old Mamaroneck Road bridge which is skewed 33 deg. If the structure were a right frame, the enclosed quantities on Fig. 2 would disappear. The quantities, introduced by the skew, produce combinations of internal stress that considerably affect the proportion-





FIGS. 3 AND 4—COMPARISON OF REINFORCEMENT IN A RIGHT AND IN A SKEW RIGID-FRAME, SOLID-SECTION BRIDGE

$4,500 had been accomplished at a total expenditure of $2,200, and that a much more sightly structure was the result. It is probable that a greater saving is effected in the Wilmont and the Old Mamaroneck Road bridges, since the approaches are more affected by the decrease in required headroom. Since the methods of design have been greatly simplified, the cost of the design has also been greatly reduced.

The demonstration of the method of analysis is too long and complicated to be given in this article, the purpose of which is merely to record this new development

ing of the structure, as may be observed by comparing Fig. 3 and Fig. 4. Fig. 3 shows the steel of the Fortfield Avenue bridge, Yonkers, which was nearly enough a right bridge to be calculated as such, while Fig. 4 shows the steel (in the top of the frame only) of the Old Mamaroneck Road bridge which has about the same span, measured perpendicular to the vertical walls, as the Fortfield Avenue bridge.

The proven advantages of rigid-frame bridge construction, developed by the Westchester County Park Commission, are of sufficient importance to make the solution

of this new problem of great value. Automobile traffic has brought about a nation-wide demand for the elimination of dangerous grade crossings and made obsolete the practice of kinking a highway to avoid the construction of a skewed bridge. Also, the failure of many skewed arches and uncertainty as to the safety of others demand a careful and accurate analysis of future designs. This new design method makes this possible for the single-span bridge, and the commission is now studying the solution of the skewed multi-span rigid-frame bridge. Two- three-span skewed bridges have been built of ribbed construction, but the solid-section construction would be a great improvement.

The advantages of rigid-frame bridges were underestimated in the article in *Engineering News-Record*, April 29, 1926, p. 686. Since the publication of this article, more careful direct comparisons have been made, by means of designs and estimates, of different types of construction for the same location. A few of these comparisons are shown in Tables II and III. The construction of a large number of bridges by this commission during the past five years verifies the results in these tables.

The New York state highway department, Connecticut state highway commission and the New York Central R.R. have now applied the methods of the Westchester County Park Commission to the design of some of their bridges, and the results of their experience will be followed with interest. The officers of the Westchester County Park Commission are: V. Everit Macy, president; Arthur W. Lawrence, vice-president; Jay Downer, chief engineer; and Leslie G. Holleran, deputy chief engineer.

Equipment to Replace Hand Tools In Surfacing Asphalt

California Highway Department Experiments on Two Paving Jobs with Improvised Devices Show Encouraging Results

EXPERIMENTS to develop mechanical equipment that can produce a finish on asphaltic concrete surfaces comparable to the very smooth surface obtainable on concrete with modern mechanical equipment have been carried on under the direction of C. S. Pope, construction engineer, Division of Highways, California Department of Public Works.

Early in 1927 trials were made with a blade strike-off riding the side forms of an asphaltic pavement. Before using the blade a toothed scarifier was drawn over the asphalt to loosen the material to its full depth so as to secure as nearly uniform density as possible. The implements used were hastily constructed devices, were drawn by hand and were not on the work long enough to afford a very thorough tryout. However, the results were so encouraging that on the completion of this contract they were shipped to another paving job where they were used throughout the work of resurfacing of 4.5 miles of concrete base.

This base, 4 in. thick, was laid some 13 years ago to a width of 15 ft., and it was this year widened by 2½-ft. concrete shoulders 7 in. thick and then resurfaced. The shoulders were constructed to a grade flush with the edges of the proposed asphaltic resurface, that is, 2 to 4 in. above the old concrete base, this height depending upon the condition of the old base.

The asphaltic mixture contained aggregate up to 1¼ in. and included approximately 34 per cent passing a standard 10-mesh sieve. After this mixture had been spread from trucks and raked by hand to an even surface, a

HAND-OPERATED RAKE LOOSENING ASPHALT MIXTURE

toothed scarifier was used to loosen it up to full depth. This was followed by the blade which cut the surface and carried the excess mixture with it to the end of the spread.

In the blading operation it was often found necessary to cut high on the first one or two trips of the blade so as to reduce to a minimum the material that would be carried off as excess in the final cut. Scarifier and blade were mounted as separate units on timbers that spanned the full width of the course and were supported by steel shoes running on the concrete shoulders. At first these units were drawn by hand. Trucks were then tried, and finally a horse was hitched to each end of the timber; this method, being found the most satisfactory, was continued to the completion of the job.

The work done under this contract adjoins another asphalt resurfacing job on which the same contractor had just finished paving with the same crew and under identical specifications except as to the mechanical surfacing. Presumably the difference in the finish, if any, would be due to the different methods employed. One difference observed was the uniformity of the mixture and the freedom from rock pockets that marked the sur-

OPERATING THE HAND-DRAWN STRIKE-OFF TEMPLET

face finished with the blading device. A vialog test to measure the roughness showed the hand-spread asphaltic surface to average 22.6 in. per mile while the mechanically spread surface averaged 20.2 in. per mile. In view of the crudeness of the implements used in surfacing, this showing was considered most encouraging.

In a mechanical tamper which the construction department is now building, the arrangement will consist of two strike-off blades having a transverse motion, between which are set the raking teeth in frames. The additional blade will be used to cut and smooth the surface transversely after it has been raked. With this equipment further experiments will be made.

Blue Hole and Downstream End of Mound Landing Crevasse

SECOND OF A SERIES OF ARTICLES:

Today in the Mississippi Flood Area

Engineering and Human Conditions in the Basins and Along the Levees as an Engineer Sees Them

By W. W. DeBerard
Associate Editor, Engineering News-Record

II—Closing Mound Landing Crevasse

LAST spring, long before the water ceased flowing through one of the largest and most destructive crevasses ever experienced in the main Mississippi River levee system (at Mound Landing opposite Arkansas City), survey parties of the Mississippi River Commission had sounded out the 100-ft. "blue hole" and the engineers had made alternate plans for closing the gap. It was early recognized that for such a job, involving at least 2,250,000 cu.yd., the season before another flood might come would be all too short. In fact specifications were prepared and bids asked while water was still on much of the area to be worked over. While the necessity of keeping within the allotment of funds, $500,000, was a consideration, guarantee of time of completion was the really essential factor always kept in mind. Contractors bid on the work, but from the nature of the job could not well meet the time guarantee necessary, so the work had to be done by field forces of the M.R.C. (Mississippi River Commission), using their own equipment plus a 21-in. dredging outfit from the Engineer Office, located at Jacksonville, Fla. On Dec. 1 the job was essentially completed.

Mound Landing levee has been in danger for some years due to the character of material available and the caving bank, although the latter did not cause the break. The immediate cause was a supersaturated levee with the line of saturation coming to the surface just above the banquette in material that might almost be said to be liquid under such circumstances. It is a brownish-yellow silty loam that a small amount of water seems easily to saturate so that its angle of repose is extremely flat. Though a sub-levee had been built just previous to the 1922 flood it was only with an enormous amount of mat work on the water face and sandbagging on the back face that the main levee was saved in 1922. The 1927 flood had just begun to spill over the sandbag topping in many places when a section of about 350 ft. blew out down to banquette elevation. This was on April 21 at 6 a.m. with a stage of 2.55 ft. above any previous record and 0.05 ft. above M.R.C. provisional grade. The high stage was due to waters from the Arkansas and White Rivers which were bringing down flows from excessive rains, continuous for 16 days, in the lower watershed. On the same day two breaks occurred in the south bank levees of the Arkansas River due to stages 2 ft. higher than the levee top. As a result of these three breaks the river stage dropped 5.8 ft. in two days, but water continued to pour through the breached levee until into July. The Mound Landing water coursed east across country for 50 miles and downstream to Greenville which it kept under water for 8 weeks. It returned to the river below the levee ends of the Yazoo and main river opposite Vicksburg. It accentuated the backwater overflow in the Yazoo delta, producing heavy currents in the upper portion of the delta. The Arkansas breaks similarly filled up the Tensas Basin on the west

side, contributing largely to the breaks at the Bayou des Glaises at the head of the Atchafalaya River three weeks later.

The blue hole at Mound Landing crevasse, so called because of the ultimate clearness of the water when river water has ceased to bring in sediment, attained a depth of more than 100 ft., later silting up to from 60 to 80 ft. deep. About a mile from the levee line the blue hole divided into two scours or guts, the longer of which connected with Grassy Lake, an old chute of historic origin. The limit of both guts was about 6,500 ft. at which point they were each about 300 ft. wide and 1,400 ft. apart. Sand from the excavation spread out over the surrounding plantation in irregular bars up to 4 to 5 miles away. Drainage ditches were completely filled in places. Most of the sand lodged on the plantation of the Delta Pine and Land Co., a syndicate largely owned by English cotton mills. The sanded land can be brought back into cultivation eventually by growing small grain crops on it for several years. That not covered with sand is greatly enriched. The state of Mississippi pays for land condemned and that damaged by inclusion within the new levee loop (about 400 acres in this case) on an appraisal basis, so that it is probable the syndicate will benefit in the long run, since the fertilizer effect will considerably more than balance the loss due to lands lost or covered with sand.

Type of Repair—With closure this season so necessary three principal methods were studied, taking into consideration the desirability of setting back the levee from the caving bank, the possibility of straightening it somewhat, the character of the foundation, quantities of material required and equipment available. The first method proposed was to use dredges only and to replace the levee on the old line with a sand fill. This line was early discarded and the location moved back some 1,800 ft. to avoid the 100-ft. fill. At that time it was not realized that the river would fill in 40 ft. during the time of recession. It was proposed to fill in the top 24 ft. by sheer boards, increasing the approximate natural 1 on 10 slope of the material to 1 on 5. This scheme involved 3,000,000 cu.yd. of material. The location is shown in Fig. 1.

In the second, a line crossing the blue hole 2,500 ft. from the breach was chosen. The same section was to be used. Crossing the blue hole was to be done by dredge fill (1,500,000 yd.) and levee-machine fill (785,000 yd.).

The final method involved a much larger loop, crossing the two guts of the blue hole 6,000 ft. from the break. The levee is located far enough away from the caving bank to obviate any difficulty on that score for many years to come, the foundation is better than at either of the other lines, there being less of the silty loam, and it practically fills the ends of the two guts, permitting the material between them to be used for a dredge pit. The dredging could be completed in about the time required for the three levee machines to complete the land sections and then continue on top of the sand or dredged fill. The quantity involved was about the same as in the

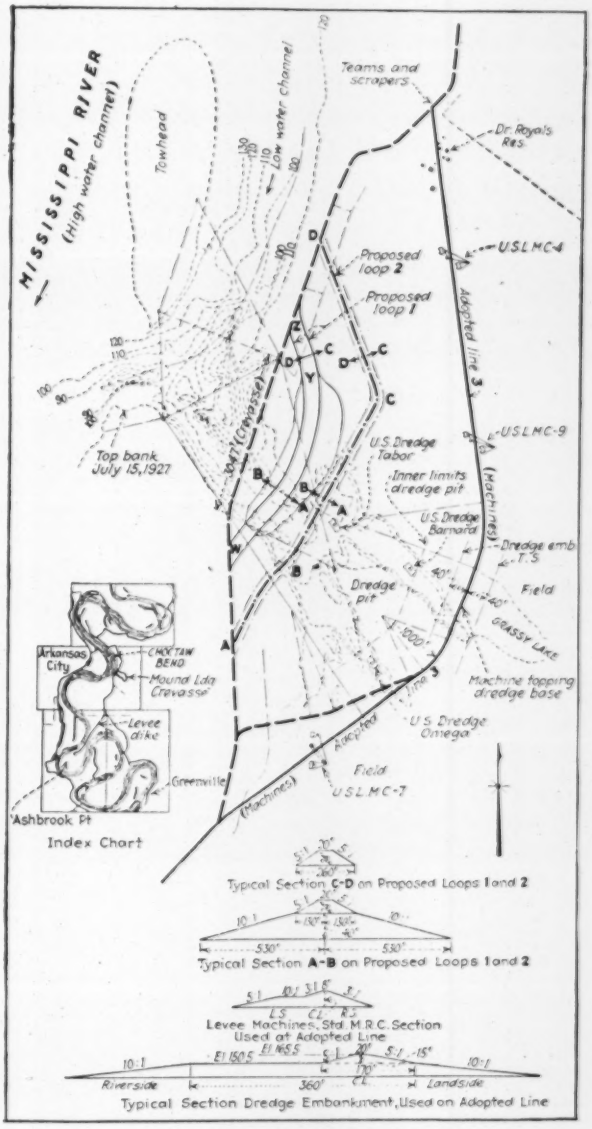


FIG. 1—CREVASSE IN MISSISSIPPI LEVEE AT MOUND LANDING

Showing proposed and adopted location of levee looping the crevasse.

second method, 2,250,000 cu.yd. The hydraulic-fill section was given a flat crown of 350 ft. on top of which

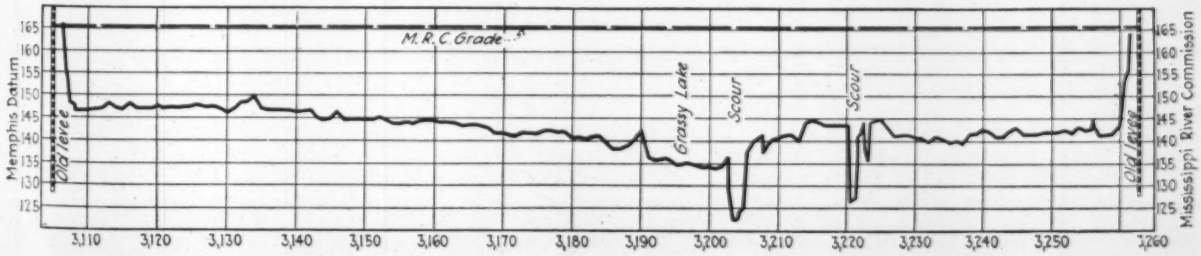


FIG. 2—PROFILE OF MOUND LANDING LEVEE SITE

the last 15 ft. is brought up by levee machines to a 5 to 1 slope and 20-ft. crown. The long banquette was located on the river side. Rye will be grown on the sand this winter as wave protection until Bermuda grass can get a foothold. Levee machines used both sand and original material. To brace the toe the borrow pits were filled by the dredge after the levee machines had finished the top levee.

Ends of the new loop, which is nearly 3 miles long, were tied into the old levee by team-and-scraper contracts. The old levee on the downstream side of the break will be leveled back to the new section to prevent eddies.

Sections—In the machine work the regular M.R.C. standard section based on the flood of 1913 was used allowing for a 25 per cent shrinkage. No allowance is made in this section for difference of material when put up by the levee machines but for the dredged sections the 350-ft. crown and 10 to 1 slopes were arrived at, taking advantage of the experience of the Dredging District staff. The top levee with 5 to 1 slopes and 20-ft. crown was considered as steep as the sand would stand under wave action and also produce a line of saturation well below the line where the 5 to 1 slope meets the crown of the dredged portion. There is some discussion of a change in the machine-made section and flattening the slope above the banquette so as to eliminate the weak line where the banquette and top slope intersect. This weak line develops only when the water rises above the designed high-water elevation.

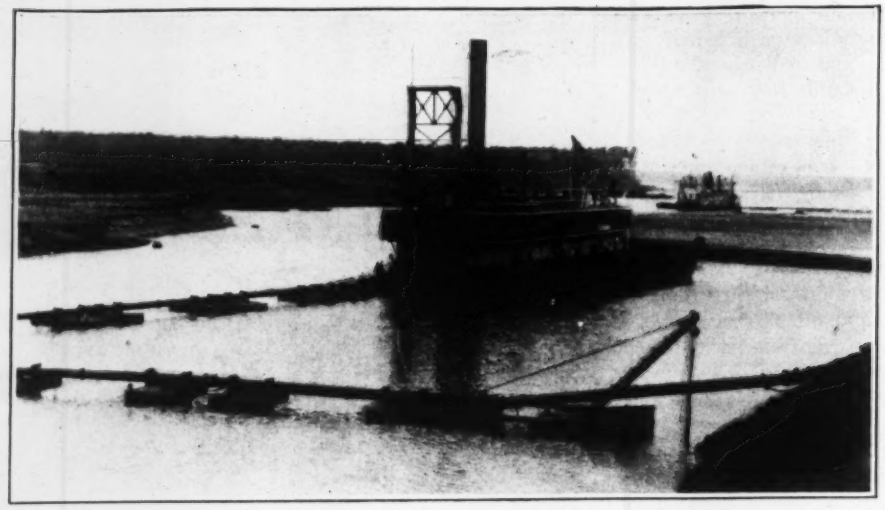


FIG. 3—DREDGE PUMPING SAND INTO LEVEE
Two of the three used at Mound Landing.

Material—The majority of the material is buckshot clay, a kind of gumbo that crumbles when dry, shrinks materially on drying and probably requires a year before the large masses or blocks as they come from the 6-yd. shovels become thoroughly homogeneous. Inspection of embankment, perhaps a week old, showed transverse cracks up to 4 in. wide extending downward 2 to 3 ft. every 20 to 30 ft. along the crown of the levee. No apprehension is felt over these cracks as even rains quickly swell the material to a homogeneous mass. Another material is brownish, silty loam that is extremely susceptible to saturation with a small amount of water. Extra dredged material is to be put into the borrow pits opposite some 1,000 ft. of levee having this kind of material in order to give a bracing effect to the toe. The sand pumped by the dredges is quite fine and carries some buckshot. Practically all silt washes out. While the sand deposited beyond the end of the dredge pipe naturally takes a slope of 10 to 1 this slope becomes 5 to 1 or steeper at the water's edge of the waste pools.

Progress—In August three tower levee machines with 6-yd. buckets, four auxiliary class 9½ draglines and two dredges started operation. The two dredges placed 300,000 cu.yd. in August, 350,000 cu.yd. in September and, with an additional dredge secured from the Engineer Office of Jacksonville, Fla., completed the 887,000 cu.yd. of the original dredging project on Oct. 30, 16 days ahead of schedule. The three levee machines duplicated the 300,000 yardage of the dredges in August, placed 343,000 cu.yd. in September and 307,000 cu.yd. in October, making a grand total for all outfits of 1,830,000 cu.yd. or 81 per cent complete by Oct. 31. By Nov. 15, when this was written, there remained less than 15 days' work to bring the job to a close. This record was made possible only by working the equipment to the limit, about 90 per cent of the available time. The dredges operated three 8-hour shifts and the levee machines two 10-hour shifts. Full 10-hour work was obtained, as the shovels began to dig when the whistle blew.

More than 2,250,000 cu.yd. have been placed in less than 4 months, closing in record time the greatest crevasse in the history of the commission. Needless to say it has brought a distinct feeling of relief to the people who live back of the levee and who will be ready in a month or six weeks to prepare the ground for the 1928 crop.

In general, closing crevasses is simply a matter of levee building around the blue hole. This year with its dozen breaks in the main levee and more than 200 on tributaries, the Mississippi River Commission has had to mobilize its entire construction equipment to that task. By the first of the year protection by levees will again be in the same relative position it was a year ago with the exception that the weak spots were tested, failed and are now eliminated by being rebuilt. While elevations and standards have not been raised, in effect the system is a better one because of defects being found and remedied.

Personnel—The staff of the Third District of the Mississippi River Commission under which the Mound Landing job was done consists of Major John C. H. Lee, Corps of Engineers, U. S. Army, district engineer; Engineer A. M. Todd, principal assistant in charge of engineering; W. L. Lipscomb, associate engineer in charge of levees; C. B. Allen, general foreman; and Eric C. Dye, foreman in direct charge. The dredges, ordinarily engaged in summer, principally in deepening cross-over channels, were assigned from the Dredging District of which Major Stuart C. Godfrey, Corps of Engineers, U.S. Army, is district engineer, with Capt. W. E. Franks, local superintendent in charge.

European River-and-Harbor Laboratories Revisited

Great Progress Observed in These Unique Institutions After Three Years—More Laboratories Being Built—Study of Models Applied Effectively to Varied Problems

By John R. Freeman
Consulting Engineer, Providence, R. I.

GREAT PROGRESS in the study of large-scale hydraulic problems by laboratory research was noted by the writer at leading European hydraulic laboratories recently revisited after an absence of three years. *Engineering News-Record* on Jan. 29, 1925, published notes on an earlier visit to German laboratories; during the past summer more laboratories were visited, in Germany, Italy and Switzerland. The work being done proved even more inspiring than that seen on the former visit, and presents great encouragement for the hope that important work could be accomplished in similar laboratories in the United States.

Laboratory Types—Three types of hydraulic laboratories are to be seen; they are most fully developed in Germany. First, there are those dealing with river control and harbor work; some are university laboratories (usually in the department of civil engineering), while some are government research laboratories. Second, there are hydraulic power laboratories, for the study of hydraulic turbines, centrifugal pumps and the like, in the department of mechanical engineering of the universities; admirable institutions of this type exist at Charlottenburg, Dresden, Hannover and Munich. Third, there are the laboratories concerned with naval problems, such as the reactions of various shapes of vessel to waves, skin friction, and the design of screw propellers for maximum efficiency to meet various conditions. The outstanding examples of this type are that at Hamburg, under Dr. Kempe, which is the most complete, and its predecessor at Charlottenburg, under Dr. Krey. Although these two laboratories were built independent of technical schools, for research primarily for the German navy and German merchant marine, both are now supported largely by fees from research for shipbuilders outside of Germany.

In all three types of laboratory, it will be understood, research is carried on by means of models. This is an old and recognized practice relative to power and naval problems, but less old and far less acknowledged in the field of river and harbor problems. Yet the value of model study in the latter field was established long ago in England by Osborne-Reynolds and Vernon Harcourt, in France by Fargue, and in Germany by Hubert Engels. Many years have elapsed without the doctrines of similitude which these men developed finding broad application to river and harbor problems in the United States.

Doubtless the reason for this delay is that in the United States these latter problems have been almost exclusively in charge of men trained not in hydraulics but in military science, and functioning under a system which soon shifts the engineer-in-charge to a new location and makes him chiefly a disbursing officer rather than a researcher. This is very different from the system which, for example, kept the great engineer Franzius continuously at work for many years on the problems of improving the river Weser between Bremen and the sea, while its navigable depth was being increased from 6 ft. to about 23 ft., and nearly 40 ft. was made available at Bremerhafen under difficult conditions of vast quantities of sand drifting into the harbor entrance under tidal and littoral currents. The writer spent a day on the river Weser with Mr. Plate, chief engineer of the harbor improvement board, and was greatly impressed with the difficulty of its problems and with the success of forty years of following along one consistent line of research by hydraulic experts under an administration in which changes of personnel were few.

These problems of the river Weser, its long lines of training walls composed of fascines loaded with stone, and the careful adjustment of width and dredged depth to scouring velocity, were largely worked out prior to the development of harbor research with models; but three years ago an elaborate harbor model was in use at Charlottenburg for studying currents and avoiding sand bar formation in the harbor of Bremenhafen, prior to building a large dock.

Although much which is highly interesting could be said of the water-turbine and naval laboratories, the present remarks will deal only with the river or "flussbau" laboratories, which are now devoted chiefly to problems of water power, flood relief and navigation.

Wilhelmshafen Harbor Laboratory—As already indicated, some research work of great importance is being done under government auspices, as distinguished from university work. The most remarkable of these government laboratories is that at Wilhelmshafen. In this laboratory, which is under the direction of Dr. William Krueger and his chief assistants, Dr. Luders and F. Markworth, demonstrations of some of the special investigations in river and harbor work were performed for the writer, such as finding the best location for dikes and groins for controlling the vast beds of drifting sand which make this harbor difficult to maintain under a scant tidal scour and with no important river coursing through. The chief problem for this laboratory is to find methods for causing natural forces of scour to keep the main harbor channels clear without large recourse to dredging. The normal range of tide here is about 12 ft., with occasional wind-tides 13 ft. higher, and a range from highest to lowest of 31 ft., requiring dikes built up to 16.5 ft. above the marsh level. Studies of successive changes in shore line during the past 800 years show progressive subsidence of the land for some miles back from the shore at the rate of about 10 in. per century.

Here, as at Bremerhafen, the principal objective is control of the great burden of shifting sand, drifting to westward along the sea coast, and tending to clog the harbor entrances. Deposit at the rate of 10 ft. per year has been found in the water samples from off-shore at Bremerhafen. The change from month to month and year to year in elevation of bed at representative spots around the harbor is carefully studied.

Among the fascinating features of this laboratory are

its flexibility, the ease with which the position of training walls or groins can be shifted, the facility of changing the course and velocity of the tidal currents, and the clearness with which eddies and spiral currents are made visible by white paper-pulp floating at various depths and by dye crystals thrown upon the bottom which dissolve and mark the stream lines.

The laboratory was built close beside the harbor for special study of the harbor problems of Wilhelmshafen and Helgoland, which it seems to be in the way of solving successfully. To enable the laboratory to reproduce the actual open-water conditions, observations are made on the course of currents off-shore and in the harbor by means of sheet-metal vanes of 6 sq.ft. area suspended from floats and kept a few feet above the harbor bed to measure the current that produces scour. Then, corresponding currents are produced in the laboratory model by means of automatically controlled inlet valves, moved by clockwork and cams.

This Wilhelmshafen laboratory, a quite special tool, naturally differs from all other European river-and-harbor laboratories.

In the presence of this work close to the practical problem, one cannot escape the suggestion that a similar laboratory at New Orleans, Greenville or St. Louis could accomplish much. The cost of the unsuccessful experiments along the Mississippi and the Colorado would have been lessened, and greater success attained, had a model laboratory been available.

Laboratory Idea Spreading—The hydraulic laboratory idea has crossed the Alps into Italy, but is not yet in full strength there. Both at Milan and at Padova, whose engineering schools the writer visited, the laboratory rooms set apart for hydraulic experiments and instruction gave evidence that activity in these lines is not as advanced as it is in Germany, Austria, Norway and Sweden. It is said, however, that a new and larger hydraulic laboratory is planned at Stra, near Padova, following an extensive study of foreign laboratories by Professor Scimini. Since all northern Italy is alive with industrial development and hydro-electric plant construction, the relatively small development of hydraulic laboratories is surprising, especially so in view of the thousand-year-old problems of the Po and Adige Rivers nearby.

At Zürich, Switzerland, the technical university soon is to have a river laboratory, under charge of and designed by Prof. Meyer-Peter. A new 3-story building 235 x 66 ft. is to be wholly devoted to this. Among other apparatus it will contain a long tilting flume as well as a stationary flume 6 x 6 ft. in which water currents 2 ft. deep and with velocities up to 15 ft. per second can be produced by pumping. This flume is intended primarily for research on the transportation by water of coarse gravel in stream beds under conditions of depth more nearly approaching those found in nature than has been practicable with laboratory apparatus hitherto available. This problem of the disposal of the vast quantities of coarse gravel carried down by mountain streams to the intakes of power plants is of great importance at some of the developments in Switzerland and other central European countries.

Karlsruhe River Laboratory—Some of the work in progress at the two most active river laboratories in Germany, Karlsruhe (Prof. Rehbock) and Charlottenburg (Dr. Krey), may be noted first.

The engineering school at Karlsruhe, which has been in existence 102 years, has a new hydraulic laboratory built five years ago. At the time of the writer's visit, during vacation time, several major problems from Prof. Rehbock's consulting practice were under active investigation by means of models. On the top floor was a large model on the scale of 1:250 for studying the regulation of the Guadalquivir River in Spain, where, in connection with a land reclamation project, it is proposed to develop 70,000 hp. at peaks from an ordinary flow of 9,000 sec.-ft. under a fall of 26 ft. Much of the reservoir area and the course of the river below the dam was included in the model for the study of river currents. On the next floor was a model, scale 1:200, of a proposed design for an arch dam at Jandula, Spain, 300 ft. high, with crest of 900 ft. and with a side-spillway 650 ft. long. A maximum flood of 50,000 sec.-ft., or 6½ ft. over the crest, has to be provided for. Various forms of flood spillways and of energy absorbers at the foot of the overfall were being tested for efficiency. Models for flood-channel developments on the Rhine, Aar and other rivers, and for improvement of power headworks, were seen. In a large flume with glass sides were studied the effects of gravel flow below a high overfall dam and of a toothed weir at the foot of the fall for destroying the surplus kinetic energy of the discharge, to prevent erosion. A model of a flood-gate of unprecedented size, about 57 ft. wide by 26 ft. high, was being tested for study of control of outflow and coefficient of discharge.

Results from previous research by means of models, Prof. Rehbock stated, have been large reductions in cost and gain in efficiency of power developments. In a number of cases he has repeated his laboratory tests with models built to widely different scales, and has also experimented with the distortion of the vertical relative to horizontal scale; within limits, he says, important departures can be made from the strict mathematical theory of similitude, especially in relation to time factors and size of sand grains.

Charlottenburg and Potsdam Laboratories—We found the river laboratory of the Charlottenburg Technical University, formerly under Dr. de Thierry and now under Dr. Ludin, being used among other things for experiments on a model of the River Shannon power development in Ireland, the particular problem being that of arranging spillways to prevent surges in the approach to the locks following a sudden turbine shut-down.

Near this laboratory but independent in control, although used in its instruction in naval architecture, is the important government research laboratory for water structures and shipbuilding under Dr. Krey. Although this was founded and maintained primarily for research on problems of the German government relating to waterways and navigation, Dr. Krey has been permitted, under a scarcity of appropriations and some temporary slackening of government work, to take in many problems from outside, the income from which aids in the upbuilding and support of the laboratory. The laboratory is now being enlarged, for it was crowded by the problems in process. Dr. Krey has found need for even larger facilities than the island at Charlottenburg will permit, and is now beginning certain researches on a larger scale in a new out-of-doors laboratory that is being gradually built up in a 50-acre tract beside the canal near the river Havel at Potsdam, twenty miles away.

In Dr. Krey's laboratory, researches were in progress on dams, sluiceways and spillways. One of particular interest related to a proposed series of large navigation locks, in which water was to be economized and surges

lessened by a system of intermediate storage basins. A system of interlocking valve control was being worked out experimentally with marvelously complete automatic graphic records.

At Danzig, under Prof. Winkel, formerly with Dr. Krey, there was study by means of models of the effect on sea beaches of wind, waves, tides and littoral currents, under conditions perhaps similar to those found on the New Jersey coast. Miniature waves 3 or 4 in. high were rolling in on the beach with striking resemblance to waves in nature ten times as large, and the tidal currents causing drift of the sand all were carefully regulated according to the mathematical doctrine of dimensional analysis, while groins of different shapes for preventing the littoral drift were under experiment.

The Dresden laboratory is noteworthy for being the place where Dr. Hubert Engels, still emeritus director, first worked out broadly the method of river research by models. All of the ten or more "flussbau" laboratories of Europe have had the benefit of Dr. Engels' wise counsel.

Here we found the large glass-sided flume under reconstruction—nowhere does a laboratory stand still. Some experiments on currents set up at bridge piers were seen here, with depth of flow limited to 8 to 10 in. for visibility. The movement of the sand grains as they shifted position was very interesting to watch.

The Darmstadt laboratory, formerly under the late Dr. Koch and now under Prof. Thürnure, carries on many practical researches brought in from consulting practice. Experiments on a model of a sluiceway on the river Saar at Mittlach were said to have resulted in lessening the entrance head by 15 per cent and lowering the flood height over the dam crest from 10 to 5 ft. There was a set-up for study of the canalization of the lower river Main, and there was apparatus for the study of toothed sills and other constructions designed to absorb energy at the foot of ogee overfalls, and for study of prevention of sediment deposits in power canals.

Dr. Franzius at Hannover was working on the determination of the coefficient of friction within a mass of wet sand; the apparatus was designed for determining the loss of resistance against sliding presented by high earth dams and was on a large scale. The results may be valuable in explaining earth slips like those of Necaxa, Calaveras or Wachusett. Dr. Krey at Charlottenburg was carrying on some extremely precise tests on earth friction, with a very different apparatus, also with reference to stability of earth dams and retaining walls.

Broadening the Field of Activity—It is noteworthy that much of the advance in European laboratory practice has come from the call for more data by the engineers in charge of great works of river development for power. Problems such as those which come to our U. S. Army Engineers in their river and harbor work now occupy hardly one-half of the activities of these flussbau laboratories. The opportunity presented to the professors at the technical universities to utilize their laboratories in connection with their consulting practice brings remarkable opportunities before the students and promotes much research work that would otherwise be impossible.

Conclusion—There is in these European hydraulic laboratories increased activity, and there is increased confidence in the value of dimensional analysis by the use of models. It seems clear that the model laboratory plays an important part in contributing to the reforming of the design and to reduction of cost of structures for power development and those for river or harbor improvement and for navigation.

Chinese Flood Problems Similar to Those of Mississippi

Levees Found to Be Most Satisfactory Form of Protection on Similar Alluvial Rivers in China

[Struck by the similarity between the floods and flood problems of the Mississippi River as reported in our pages during recent months, G. W. Olivecrona, engineer-in-chief, Board of Conservancy Works of Kwangtung, China, sends a copy of a paper which he had presented at Canton Christian College dealing with the flood problems of Kwangtung. In sending the paper, Mr. Olivecrona said: "From this pamphlet you will find that we have to face the same flood problem here in Kwangtung as you have with regard to the Mississippi River. After careful investigations, I have arrived at the conclusion that the construction of sufficiently high and strong levees is the only practical solution of the flood protection problem here, in spite of the fact that the levee in the upper course of the river reaches a height of 35 ft."

A considerable portion of the paper deals with descriptions of the four rivers of Kwangtung Province and is not of special interest except to those familiar with the region, but certain observations which he makes are of quite general interest, particularly in relation to the Mississippi River flood problem. For that reason abstracts from his paper are given below.—EDITOR.]

ON A stretch of China coast 60 miles in length no less than four rivers debouch into the sea, viz., the West, the North, the Pearl, and the East rivers, discharging during the rainy season about 2,800,000 sec.-ft. All these four rivers have together built up the Canton Delta, a vast plain of alluvial soil which covers an area of about 3,100 sq.mi. south of Canton and west of Cheklung. This area has a population of 8,000,000 to 10,000,000 people.

At flood time, the rivers rise tremendously. During the big floods of 1915 water at Wuchow rose 82.3 ft. above the lowest water level on record. The average rise is about 61 ft. and such floods are generally not dangerous to the dikes along the river. During the year 1915 the quantity of water passing Wuchow at the highest stage was 2,100,000 sec.-ft. The highest rise in 24 hr. at Wuchow was 22 ft. during the summer flood of 1924.

If a river is confined within dikes, as is the case with the Kwangtung River, no rise of the land surface by silting is to be counted on, so long as the dikes are intact. Following the growth of the river towards the sea, the gradient must be maintained, and a rise of the bottom follows. The most effective means to stop the growing divergence in level between the river bottom and the land would be to let the water free to spread out over the land and there to unload its silt and raise the river banks. To keep the bottom low by permanent dredging only is a very expensive operation, which can scarcely be resorted to in rivers of such magnitude as those of Kwangtung.

During a period covering probably at least 800 years, the population in the south of Kwangtung has protected its low-lying land against inundation by means of extensive embankments running along the banks of the rivers

and their tributaries, also following the innumerable creeks which are in communication with the main river.

[At this point Mr. Olivecrona gives a long description of how the Chinese have raised the dikes by piling earth on top, usually borrowing too close to the slope, without giving the dike increased base width, have encroached upon the dikes for agricultural purposes, and have so far weakened them that breaks are frequent.]

The principal means suggested as remedies against floods are afforestation of the drainage basin, creating new outlets to the sea, storing the floods in reservoirs, and cutting off bends and dredging the river bed.

Afforestation of the Drainage Basin—There exists in the public mind an impression that the prime cause of the floods has been the destruction of forests in the river valleys, and that the surest way to prevent them is by reforestation.

The fact remains that in Europe as well as in America remarkable series of great floods, in land covered with woods, have not occurred more frequently *after* the forests were cut down. It is also argued by some that with reforestation, if the floods occasionally were high, they would not be as frequent. However, where long periods of records are available, they do not always verify this apprehension.

Under the assumption that reforestation would reduce the flood discharge of a stream to one-half, I have estimated the forested area that would be required to lower the flood heights in the North River to an elevation of 1 ft. below the present dike crests at Tsingyun. I have found that at least 65 per cent of the total drainage basin, amounting to about 12,000 sq.mi., would have to be covered with forest to bring about such effect.

As the only, immediate, or principal remedy against floods, afforestation is not to be recommended.

Creating New Outlets to the Sea—A scheme which has been much ventilated among laymen is that of creating an additional outlet for the West River, either to the Tongking Gulf or the South China Sea.

No less than six different passes in the mountain ranges south of the West River have been examined in order to ascertain if any possibilities exist to cut a canal big enough to lead off sufficient water, in order to prevent overtopping of the present dike systems. Not in one single instance did the topography warrant the possibility.

Storing the Flood in Reservoirs—The plan of controlling floods by means of reservoirs, in which part of the water is held back during the flood season, again to be released at a lower stage in the river, appears to have met with much popular approval.

Generally from a constructive point of view the best sites for reservoirs are found in the upper courses of the river system, and consequently the runoff in that part of the drainage basin only is regulated by the reservoir. The rest of the basin, in most cases the larger part of it, continues as before to feed the river, and the beneficial influence of the storage in the upper courses is only slight in the lower ones. Great floods do not arise from average conditions, but from exceptional variations, such as are caused by a series of heavy rains rapidly succeeding each other. Each rainstorm produces in the river a flood, whose volume may be absorbed by a reservoir or a system of them. Should a second storm sweep over the valley, a short time after the first, the reservoirs to be effective must be emptied, or their capacity doubled. To hold all the excess rainfall until low water would require reservoirs of enormous capacity. Therefore, as soon as a reservoir is filled, and has for the time played its part as a reducer of floods, it should be emptied in order to utilize the same space for a second rainfall. While reducing the flood crest at a given locality, the reservoir necessarily prolongs the period during which the river remains at a high stage. This condition is not desirable from an agricultural point of view, as it prevents the drainage of the lowland in the lower region of the river.

The prospect for introducing reservoirs along the course of the Kwangtung Rivers, as a preventive against inundation of the plains, is not especially encouraging. Let us, however, for argument's sake, presume that this is possible for the North River, and that we wish to store so much water as to keep the water level 1 ft. below the crest of the dikes in the Tsingyun region. This means at least a reduction in flood height of 5 ft. below the high-water level of 1915, which is the highest observed. It would then be necessary to store at least 23,800 million cu.ft. of water to gain the desired reduction at Tsingyun. A reservoir of that capacity would, if filled say to a height of 16 ft., cover an area of 52 sq.mi. Storing this volume would not produce a lowering of the flood height at Lupao of more than about 2.3 ft., and still less further down.

Independent of the success or failure of introducing reservoirs, the dikes in the lower course of the river must still remain as a defense against inundation, since we must keep in mind the fact that only a slight lowering of the extreme flood height would be attained by storing.

Cutting Off Bends and Dredging—A method suggested for reducing flood height is the straightening of the river by means of cutoffs. It is believed that, by cutting off one or several bends, the discharge of water will increase at such a rate as to produce a lowering of the flood level in general. Theoretically, an acceleration of the flow will follow, since shortening of the river gives to it a steeper slope. This change of condition, however, will only result in a lower flood level immediately above and in the upper end of the cutting, while, at the lower end, an increase in flood height will take place, because the water rushes through the improved section much faster than the lower part is able to carry it off. The fact is that cutoffs have been repeatedly tried in rivers as a means of reducing floods, but generally with unsatisfactory results. They afford relief in one locality, but only at the expense of other localities. Cutoffs are justified in case a higher flood level does not cause any inconvenience to the lands at the lower end, if benefits balance the cost.

Dredging of the river bed has often been held forth as the only means that would lower the flood level. And so it would, if only the once-dredged canal remained open. This is, however, not to be expected in a silt-carrying stream for the following reason. By dredging the bottom, the cross-section of the bed is made larger than before, which causes a slackening of the current velocity. This being a fact, the current is not strong enough to keep the silt suspended. It settles, and the dredged canal is soon silted again. No improvement can be obtained unless dredging operations are carried on perpetually.

It is a false supposition that the lowering of the river bottom, say one foot, must effect the same lowering of the water level. The height of the water surface in a river depends, in its lower course, upon the height of the water level at its mouth, which in case of the Kwangtung Rivers is the sea level; and no human being can change that.

Office Checking Field Operations on Georgia Roads

Demerit System Secures Promptness and Accuracy in Reports from the Field—Elaborate Voucher Checking Practiced

By Fred M. Garnett
Division Office Engineer, State Highway Department of Georgia, East Point

THERE have been many valuable and informative articles written around the field end of highway construction work, but so far there seems to be a dearth of information touching upon office practice with respect to its relation to and contact and co-ordination with field engineers and construction details. The state highway department of Georgia, at the present time, spends about $9,000,000 a year in the construction and improvement of its system of state roads. It is of primary importance that the expenditure of this money be carefully planned. It is necessary also that, in addition to planning the work, close attention be given to the details of construction and to the measurement and payment of quantities.

Demerit System for Checking Vouchers—In October, 1924, the state highway department adopted a demerit system for checking against the efficiency of the division office engineers. All monthly progress vouchers prepared by the division offices are sent to the general office at East Point, Ga., to be checked and passed upon for payment. A report is gotten up monthly and brought to the attention of the state highway engineer, and copies of this report are sent to the division offices; such a report shows the number of progress vouchers prepared by each division office, and the percentages made. In Fig. 1 is shown a monthly efficiency report. Since the adoption of the demerit system the monthly progress vouchers have but few errors. The system has a psychological effect on the division office engineers, and they strive to send in the monthly progress vouchers correctly made out. A spirit of rivalry exists and there is an incentive to be more efficient. This is believed to be one of the most effective systems devised for correcting foibles and curbing indifference to details which has sometimes led to serious errors affecting payment of work. A hitherto existing evil has been remedied by reason of the fact that the responsibility is placed squarely upon the division offices. Errors are reduced to an absolute minimum, and inaccuracy has given way to accuracy. Monthly progress vouchers are paid with prompter dispatch. The personal efficiency of each division office engineer is shown on the monthly reports, and governs largely his promotion and advancement.

East Point, Ga.
Dec. 13, 1928.

From: R. E. Adams, Office Engineer,
To : W. R. Neel, State Highway Engineer
Subject: Efficiency report on monthly and final statements

I give you below the report of efficiency on monthly and final statements checked in this office during the past month.

Div. No.	Monthly Statements	Errors	Per cent	Final Statements	Errors	Per cent	Average Per cent
1	16	0	100	4	1	75	95
2	21	0	100	5	0	100	100
3	14	2	86	4	2	50	78
4	16	0	100	0	0	-	100
5	11	0	100	1	0	100	100
6	8	1	88	0	0	-	88
7	20	0	100	2	0	100	100
8	6	0	100	4	4	0	60
9	12	1	92	0	0	-	92

Respectfully Submitted,

R. E. Adams, Office Engineer.

FIG. 1—MONTHLY EFFICIENCY REPORT TO CHIEF ENGINEER

FORM #198 REVISED
CONTRACTOR _____
COUNTY _____ PROJECT NO. _____
TOTAL work completed to _____ 192__
To accompany monthly statement No. ____.

ITEM	FROM STATION	TO STATION	PER CENT COMPLETE	TOTAL QUANTITY IN PLACE	REMARKS
1					
2					
15					

I hereby certify the above work has actually been completed

Signed _____
Division Engineer

NOTES: Number for items is to agree with numbers in agreement estimate. Station numbers to cover only sections on which work has been done. Percentage complete is per cent of total work done between stations shown to plan quantities for that item between same stations. All columns refer to total work done to date.

FIG. 2—FORM FOR CHECKING AGAINST RESIDENT ENGINEER'S VOUCHERS

Checking Intermediate Progress Vouchers— Fig. 2 shows a form used to tabulate a check against the resident engineers' monthly progress vouchers. The percentages of completion are worked out for every item appearing in the voucher; these percentages are for quantities in place, between given stations, referred to the plan or estimated quantities, for the purpose of showing where over-runs occur and status of work. This form is attached to the monthly progress vouchers when transmitted to the general office. The division office engineer acts as a sort of pivot man between the resident engineers and the general office, and the duty devolves upon him to keep in close touch with the work being done so as to prevent inaccuracies in the quantities appearing in the vouchers. In this connection the office engineer is forced to get a check on the field work done, as he is obliged to refer to the plans to work out the percentages. This form also helps to anticipate and forestall over-runs before the engineering and contingency fund is exhausted, and the project agreement has to be revised. Another purpose of this form is to keep a close check on the resident engineer. The quantities reported by the resident engineers have to be reasonably consistent with those shown on the plans, and with the use of this form errors will show up in the body of the voucher, if of a serious nature, that would otherwise escape notice where checked in a perfunctory manner.

Work Orders Protect Engineering and Contingency Funds—It is almost impossible to construct a project without variations in quantities. The estimated quanti-

ties, even though carefully worked out, are often susceptible to changes as contingencies arise in the field, and unless some check is had on this phase of work, from time to time, the engineering and contingency fund is likely to become exhausted. Heavy over-runs in quantities sometimes necessitate a revision of the project agreement to include additional funds to complete the work.

In order to keep a close check on the engineering and contingency fund, and control variations in quantities, the state highway department of Georgia employs a work order as shown in Fig. 3 which gives a comparison of original plan quantities with the revised quantities. The difference between the estimated cost of the work and the proposed cost of the changes represents the over-runs or under-runs as the case may be. The engineering costs are also tabulated on this form, and enter into the cost of the work. Inasmuch as these work orders are cumulative, they afford a good check on the status of the work, and give the cost of the over-runs and under-runs, referred to the engineering and contingency fund, thus establishing an insight into the probable cost of the variations in quantities before the close of the work.

The resident engineer prepares these work orders as changes become necessary in the field, and transmits them to the division office to be checked and approved, after which they are sent to the general office for final approval. Work orders, when approved, become the authority of the resident engineer to make these changes.

STATE HIGHWAY DEPARTMENT OF GEORGIA — SAVANNAH DIVISION NO. 7

PROJECT F. A. 261 GLYNN COUNTY BRUNSWICK-BROADFIELD ROAD
DIXON CONTRACTING CO., CONTRACTORS

TABLE SHOWING OVER-RUNS AND UNDER-RUNS TO ACCOMPANY STATEMENT NO. 8 FINAL

Agreement Estimate Quantity	Final Quantity	ITEMS	Unit Price	Over-run Quantities	Under-run Quantities	Over-run $	Under-run $
		Totals				1461.77	3071.57
		Under-run					1609.80

O.K. _____ Resident Engineer

Approved _____ Division Engineer

FIG. 4—TABULATION OF OVER-RUNS AND UNDER-RUNS FOR FINAL VOUCHERS

Final Progress Vouchers—The federal government, through the Bureau of Public Roads, requires a certain amount of specific information in connection with final progress vouchers before payment on work is authorized. A final voucher must of necessity be correct, and for this reason calls for a lot of refinement in details not ordinarily required in an intermediate voucher. In co-operating with the government, the state highway department of Georgia has worked out and put into practice a system which seems to meet with general approval. Fig. 4 shows a table of over-runs and under-runs of quantities to accompany final vouchers. Every over-run and under-run appearing in this table is explained in writing. In addition to this, all contingencies are explained in detail, in such a manner that anyone unfamiliar with the work can understand the reasons for these expenditures.

A special feature of the Georgia policy in preparing the final vouchers is the supporting sheets which are attached to the vouchers. For every item constructed, a table of quantities is prepared showing the station numbers with an itemized statement, Fig. 5. This compels the resident engineer to keep an accurate record of all work performed. Field measurements are taken of all

FORM H.D. #187 STATE HIGHWAY DEPARTMENT OF GEORGIA

CONTRACTOR _____ WORK ORDER NO. _____

Address _____ Project No. _____

Resident Engineer _____ County _____

Date _____ Division _____

The following changes in work on above project have been authorized in accordance with attached letter size sketch.

LOCATION — Description and Justification of Changes

ORIGINAL PLANS

STATION	ITEMS	QUANTITY	UNIT PRICE	TOTAL
TOTALS				

REVISED PLANS

STATION	ITEMS	QUANTITY	UNIT PRICE	TOTAL
TOTALS				

Total Over-runs or under-runs in cost $ _____
Total Over-runs previous work orders _____
Total Under-runs previous work orders _____
Total Over-runs or under-runs to date _____
Amount spent for Engineering to date _____
Grand Total $ _____
10 per cent Engineering and Contingencies
Project Agreement Estimate
Balance _____
Estimated Engineering and Contingencies to complete project _____

Requested _____ Resident Engineer

Recommended _____ Division Engineer

Approved _____ State Highway Engineer

Approved, Bureau Public Roads _____ Engineer

FIG. 3—WORK ORDER COMPARES ORIGINAL AND REVISED QUANTITIES

PROJECT 369-A TOOMBS COUNTY

TABLE SHOWING CONCRETE PIPE CULVERTS IN PLACE TO ACCOMPANY STATEMENT No. 5 FINAL.

CONCRETE PIPE CULVERTS IN PLACE

STATION	LIN.FT.PIPE PLACED 15"	18"	24"	36"	ENDWALLS STRAIGHT	CU.YD.CONCRETE CLASS "B"

O.K.

_____ Resident Engineer

Approved _____ Division Engineer

FIG. 5—FORM FOR REPORTING QUANTITIES

quantities before the final voucher is drawn up, and supporting sheets attached. The final voucher is sent to the division office where it is given a thorough check. If any anomalies are detected the resident engineer is called upon for explanations, or reports to the division office to straighten the matter out. Copies of the approved final vouchers are mailed to the contractors. In case the contractor so desires, he can satisfy himself that the quantities are correct by checking the work from the final voucher in the field. The state highway department of Georgia is endeavoring to pay for work done on an accurate basis; the contractor gets all he is entitled to receive on an open-and-above-board policy.

Check-up Party from General Office—As an additional safeguard against paying for work done on a haphazard basis, the general office sends out a check-up party to measure up quantities on projects reported completed and ready for final payment. The check-up party covers the whole state as projects are completed. This check is made independently of the division offices, and affords a convincing argument to the resident engineers that it pays to measure quantities instead of approximating them. There have been instances where structures were reported of a certain size and quantities computed accordingly, but upon measurement in the field were found to have mysteriously expanded or shrunk in size. Or, perhaps a concrete pipe would be indicated as being located at a certain station, but when measured in the field would be discovered to have strangely shifted its position. With this close measurement system in practice in Georgia, a long stride has been taken in ridding the department of the evils of carelessness, waste, and incompetency.

Long-Time Tests of Concrete Using Various Coarse Aggregates

Comparative Concrete Tests Up to Ten Years, with Slag, Stone and Gravel Aggregate, Indicate Good Concrete in All Cases

By P. J. Freeman
Chief Engineer, Bureau of Tests and Specifications, Allegheny County Department of Public Works, Pittsburgh

THE TESTS reported in this article were conducted by the writer, then (1916) engineer of tests, Pittsburgh Testing Laboratory, and at the same time a member of Committee C-9 of the American Society for Testing Materials, which was formulating the present methods for laboratory practice in testing concrete.

Purpose of Tests—The purpose of this series of tests was to:

(1) Make comparison of the crushing strengths of air-cooled blast furnace slag, limestone, granite, trap-rock and gravel, when used as the coarse aggregate in concrete. Tests were to be made at the end of 14, 30, 60 and 180 days, 1, 2, 3, 4 and 5 yr. (later extended to 10 years).

(2) Determine the corrosive tendency of sulphur in slag.

(3) Determine the effect of sulphur and other elements on the durability of concrete up to the age of 5 years.

(4) Determine the relative strength and durability of concrete made of high-magnesia low-lime slag and low-magnesia high-lime slag.

Preparing the Specimens—All cement was purchased at the same time, and found to comply with the requirements of the A.S.T.M. in force in 1916. The entire amount of fine aggregate, a well graded sand representative of that which is at present used in the Pittsburgh district, was obtained at one time.

As the various coarse aggregates were received they were separated into four different sizes by screening through iron plates having circular holes of the following diameters: 1½, 1¾, ½ and ¼ in. The different sizes were stored separately and then recombined by mixing equal quantities, by weight, of each size. This was done in order to put all of the different kinds of aggregate on exactly the same basis, since there was no uniformity in the grading of aggregates received from the widely separated localities.

The proportions used were 1:2:4 by volume, the quantities for the batches being carefully weighed after the weight of the sand and coarse aggregate had been determined. These weights were checked every day on account of the slight drying out from exposure to the air in the laboratory. The weight of the cement was taken as 100 lb. per cu.ft., which was laboratory practice at the time these tests were started. Preliminary tests had definitely indicated that the amount of mixing water affected the strength of the concrete, and accordingly great care was used to keep the amount of mixing water as low as possible. Since a definite amount of each graded coarse aggregate was used, there was some variation in the quantity of water necessary to produce a workable concrete, but the same degree of workability, as judged by the same experienced operator, was used with all aggregates. The concrete was rodded into the steel molds in the manner which is now customary, and the molds were removed at the end of 48 hours.

All specimens were stored in damp sand for 35 days; from this time on, the storage was in a dry warm basement laboratory until the end of the 5-year period. After 5 years, all specimens except those for series P (Table II) were placed out-of-doors. Specimens in series P, which had been made as a preliminary set of tests from the same material as B, were stored in dry air until 7½ years, when three specimens were broken; the remaining cylinders were then stored in the weather until 9⅔ years, when they were placed in damp sand until tested at the age of 10 years.

TABLE I—CHEMICAL ANALYSES (PER CENT) AND WEIGHTS OF SLAG

Sample	A	B	C	D	E	G	H	L	M
Silica	35.35	36.72	34.35	31.98	35.74	33.63	35.55	31.53	35.15
Alumina	12.28	12.81	13.55	12.25	11.81	13.41	12.04	12.39	14.11
Iron oxide	0.90	1.50	1.02	2.00	0.38	1.25	0.62	0.50	0.25
Manganese oxide	0.50	0.61	0.71	0.34	0.70	0.40	0.36	0.22	0.43
Titanium oxide	0.40	0.33	0.50	0.30	0.30	0.40	0.40	0.55	0.45
Calcium oxide	40.05	40.98	45.80	31.75	42.65	39.18	41.35	32.78	38.75
Magnesium oxide	8.20	5.14	1.62	19.43	6.18	9.31	8.45	18.24	8.84
Sulphur in calcium sulphide	1.05	1.29	1.10	0.89	1.26	1.03	0.73	0.89	1.11
Sulphur in calcium sulphate	0.52	0.27	0.41	0.27	0.24	0.20	0.50	0.10	0.17
Sulphur in other forms	.....	0.12	.....	0.07	.....	.....	0.05	0.18	.....
Weight, lb. per cu.ft	66	78	79	64	75	64	84	74	82

Results—The strengths, as given in Table II, represent the average of three specimens. The variation from the average was small and for that reason the individual tests are not included in the table. The mean variation for the one year's test was 2.65 per cent, which is representative of all of the other results.

All concrete, regardless of type of coarse aggregate, increased in strength when stored in dry air up to the age of 1 year, and after that time decreased in strength so long as the air storage continued. This relationship is borne out by other investigators. The strength of the concrete was regained after storage in the weather, and at the end of 10 years it has exceeded in strength the results obtained at 1 year.

About one-half the slag-concrete specimens were made from slag produced by the quick cooling process in pits from which the slag is shipped within a few days after it comes from the furnace. The remainder of the specimens were made from slag which had been seasoned in banks for a period of 6 months in some cases, and as long as 15 years in one case.

Concrete made from slags coming from furnaces many hundred miles apart, varying widely in chemical analyses and also varying considerably in weight per cubic foot, did not vary in strength in proportion to either the weight or percentage of any chemical constituent.

The results of all tests, taken as a whole, indicate that all the aggregates tested are capable of producing concrete having a strength considerably beyond the requirements of commercial practice.

Specimens of reinforcing steel embedded in samples of the concrete showed no indication of corrosion. Examined at the end of 5 years, slight rust spots were found where air pockets had formed next to the steel, but these were common to all the aggregates.

TABLE II—COMPRESSIVE STRENGTHS (LB. PER SQ.IN.) OF SLAG, STONE AND GRAVEL CONCRETE

Results, except at 10 years, the average of 3 specimens

Sample Number Specimens 8 x 16-In. Cylinder	Coarse Aggregate	Weight per Cu.Ft. of Concrete	14-Day	30-Day	60-Day	180-Day	1-Yr.	2-Yr.	3-Yr.	4-Yr.	5-Yr.	10-Yr.	
A	Slag, Cleveland, Ohio, central furnace	135	1,941	2,525	2,930	3,753	4,498	4,357	4,222	4,143	3,742	5,300 5,326	5,313
B	Slag, Duquesne, Pa.	140	2,159	2,657	3,117	4,315	4,725	4,882	4,541	4,545	4,266	6,000	6,000
C	Slag, Youngstown, Ohio	140	2,134	2,657	3,306	4,154	5,028	4,678	4,129	4,459	4,225	6,000 5,760 5,652	5,804
D	Slag, Mayville, Wis.	135	2,206	2,653	3,403	4,309	5,050	4,894	4,694	4,979	4,265	6,000 4,960	5,480
E	Slag, Sharpsville, Pa.	140	2,484	3,075	3,365	4,803	5,388	4,740	5,269	5,396	4,653	*	*
F	Gravel, Pittsburgh, Pa.	148	2,046	2,510	3,295	3,969	4,627	4,264	4,097	4,177	3,556	5,488	5,488
G	Slag, Cleveland, Ohio, Cleveland furnace	144	2,257	2,844	3,288	4,394	4,956	4,974	4,746	4,850	4,574	5,718	5,718
H	Slag, Ensley, Ala.	143	2,109	2,752	3,289	4,451	5,105	4,810	4,714	4,427	4,048	*	*
I	Trap Rock, Birdsboro, Pa.	156	2,063	2,386	3,360	4,819	4,950	4,448	4,405	4,497	3,735	5,360	5,360
J	Gravel, Akron, Ohio	146	1,795	2,078	2,554	3,627	3,673	3,576	3,257	3,305	2,550	4,742	4,742
K	Granite, Stockbridge, Ga.	149	2,122	2,292	3,043	4,151	4,633	4,482	4,161	4,503	4,042	6,000 5,640	5,820
L	Slag, Pottstown, Pa.	136	2,187	2,650	3,289	4,184	4,649	4,718	4,619	4,672	3,966	*	*
M	Slag, East Toledo, Ohio	143	1,942	2,536	3,103	4,164	4,787	4,912	4,819	4,585	4,298	*	*
N	Limestone, Gates City, Ala.	150	1,713	1,988	3,082	4,127	4,344	3,932	3,783	3,925	3,445	4,985 5,592	5,289
O	Dolomitic Limestone, Cleveland, Ohio	150	1,804	2,360	3,604	4,724	4,904	5,260	5,454	4,913	3,856	5,951 6,200 6,698	6,283
P	Slag, Duquesne, Pa.	...	Same physical properties as No. 8, but storage conditions different; 5 samples broken at age of 7½ yr. Av. strength 3,410 lb. per sq.in.									5,366 5,912	5,639

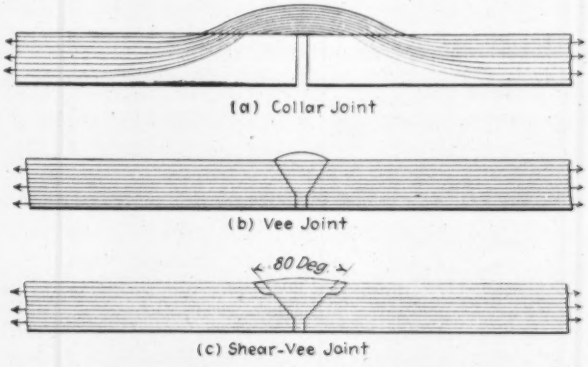
Belgian Railways to Try Steel Ties

The National Railways Society of Belgium has decided to make extensive trials of steel ties and will place an order for 60,000 with the Belgian steel interests, reports the American Commercial Attache at Brussels to the Department of Commerce. The ties will be first tried out on the line between Liege and Marloie. If these tests give good results, the society will displace wooden ties.

Bronze-Weld Joint Develops Full Strength of Cast-Iron Pipe

AS A result of an investigation made by the engineers of the U. S. Cast Iron Pipe & Foundry Co. and the Linde Air Products Co., an improvement in bronze-weld joints for cast-iron pipe has been worked out, whereby the joint is made stronger than the pipe.

Three types of joints were tested, the collar, vee and combined collar-vee. Fractures occurred in the iron next to the weld with the collar type of joint, while with the vee type failure occurred along the edges of the weld. Because of the high shear strength of bronze adhering to cast iron, and the doubtful tensile adhesion, the collar type of joint has been used practically alone up to the present time. In the studies made, beam tests were carried out on full-size 6-in. pipe sections. Under these tests the collar type joint developed an efficiency of only 55 per cent, although the fracture occurred in all cases in the iron next to the weld. Theories were advanced that the heat of the welding or the shrinking effect of the bronze collar had a decided weakening effect on the cast iron. Metallurgical and microscopic studies have shown that the heat of welding has no harmful effect upon the metal and the shrinking effect of the bronze collar is likewise of little importance as bronze is very ductile and has little strength until cooled below 500 deg. F. Further-



TYPES OF BRONZE-WELD CAST IRON PIPE JOINTS
Lines of stress transfer shown diagrammatically

more, the collar is applied progressively around the circumference of the pipe. On the other hand, the mechanical design of the joint necessarily causes the stresses to concentrate on either side of the joint (see sketch).

The early abandonment of the use of the vee type of joint was due not to defects in its mechanical design but to improper preparation of the pipe ends for welding. The finished surface of cast iron when machined is difficult to tin and as a result the bronze adheres poorly. Pioneer investigators were unaware that by searing or annealing the machine bevels to a bright red, tinning becomes very easy. As a check on this theory bending tests were made on full-sized pipe sections welded with a vee joint and the result indicated efficiencies of 83 and 79 per cent respectively for de Lavaud and sand-cast pipes. Failure occurred in every case along the vee. A thin layer of cast iron adhered to the bronze at the bottom of the vee, and a coating of bronze adhered to the tinned bevel at the top of the vee.

By redesigning this joint and adding a shear area the "shear-vee" joint shown in (c) was developed. In tests on the redesigned joint, pressures of 27,800 lb. and 24,500 lb. per sq.in. were reached before failure occurred. A 40-deg. bevel with a shear area about $\frac{3}{4}$ in. from the outside of the pipe wall was found to be the most economical design. The welding of this type of joint is automatically controlled by its design. Some of the difficulties which the inexpert welder has with the collar weld in keeping the weld metal evenly spaced over the joint are eliminated.

Hydrogen-Ion Control of Sludge Digestion

Optimum Reaction of Digestive Sludge Seems to Vary With Digestion and Nature of Sewage—Use of Adjusting Chemical Suggested

By Gordon M. Fair and C. L. Carlson

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STUDIES of the variation in hydrogen-ion concentration of digesting sewage solids have resulted in the discovery that pH control can be made to produce marked acceleration and improvement of digestion. This article describes experiments to determine the optimum reaction of pH for sludge digestion. The findings indicate that this optimum probably varies throughout the period of digestion rising from a low to a high value. Good gasification is seemingly obtained as long as low pH values are avoided.

The digestion of sewage sludge in Imhoff tanks or separate sludge digestion tanks is a biologically activated process in which complex organic materials, unstable in character, are changed into substances of simpler chemical structure and relatively stable nature. The mechanism of sludge digestion is extremely complex in its details. A statement of its nature can be made relatively simple, however, if the succession of symbiotic, metabiotic and antibiotic relations and reactions of living organisms that convert the raw material into the end products of digestion are not described. An analogy can then be drawn between it and the digestion of food in the human body. Here a separation is made between nutritive and non-nutritive elements. The former furnish energy for life processes, the latter remain essentially inert. Broadly speaking, the nutritive elements in yielding energy for life and growth are either synthesized into living matter or analyzed into excretory matter. The former is often more complex in nature than the raw material but relatively small in volume, the latter is generally simpler in nature and relatively large in volume. By a succession of life and death of the primitive organisms that live in sludge digestion tanks the nutritive matter or raw material is used up. The end product is a material no longer subject to digestion. It has become "stable."

The problem of sludge digestion thus reduces to a problem in the nutrition of those minute organisms that best and quickest bring about the desired changes in the digestible sewage solids.

The cultivation of bacteria on culture media has taught us that their growth can be stimulated, retarded or inhibited by the reaction (pH) of the otherwise unchanged medium. Recent researches in sludge digestion with which the authors as well as other workers have been identified have yielded analogous conclusions. The question then arises as to what is the optimum reaction or range in reaction of sludge digestion. It is the object of this article to give some information on this question based upon experimental evidence.

The authors have shown (*Jour. Boston Soc. C. E.*, XIV, 82-130) that the digestion of properly seeded sewage solids as measured by gasification normally proceeds in three stages. There is first a short period of relatively rapid digestion during which the pH of the sludge decreases and with it the rate of gasification. There follows an extended period of very slow or inhibited digestion characterized by low gas production and low but rising pH. The third stage is reached when the pH has climbed to about 6.8 and methane production becomes active. During the third stage the hydrogen-ion concentration commonly passes the neutral point (pH 7.0) and gas production reaches a peak rate and then drops off slowly as the digestible material becomes exhausted. The first stage may be characterized as active acid fermentation, the second as a dormant stage or period of recovery and the third as active methane fermentation. The three stages are well defined in Fig. 1, which shows the rates of gas production, pH values, and carbon dioxide and combustible gas (largely methane) ratios of digesting seeded solids plotted against time. The fairly rapid rise in pH noted at the end of the active acid fermentation period is sometimes accompanied by a minor peak in gasification. No such condition, however, is noted in Fig. 1.

Inspection of Fig. 1 shows that the periods of depressed pH and depressed gasification are associated and that they constitute many weeks of comparative inactivity. The authors have shown (loc. cit.) that this long dormant period can be eliminated by adjusting the pH of the sludge by the addition of a suitable alkaline material.

such as lime, marble dust and dolomite dust, also that at the same time gasification can be greatly accelerated. The period of digestion of pH controlled sludge can thus be reduced to a third or less of the time required for normal uncontrolled digestion. This is illustrated by Fig. 2, which shows the results obtained by adding to the sludge a quantity of lime sufficient to raise its initial

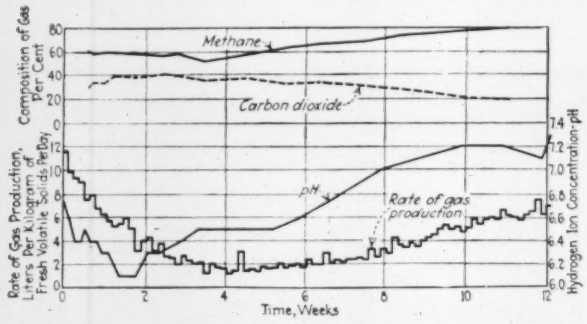


FIG. 1—CHARACTERISTICS OF UNCONTROLLED DIGESTION
Variations in rate of gasification, pH of sludge, and methane and carbon dioxide content of gas evolved.

pH to about 8.0. The digestion period of the pH controlled sludge is seen to be about 8 weeks; that of the uncontrolled sludge is estimated at 24 or more weeks. The value of pH control having thus been exemplified in Figs. 1 and 2, it becomes of interest to inquire as to what is the optimum reaction or range in reaction for controlled sludge digestion.

Experimental Methods—The experimental digesting flask used by the authors is shown in Fig. 3. The incubation mixture consisted of 1,500 grams of fresh sewage solids, 750 g. of digested solids and 750 g. of water. This gave a seeded sludge in which the ratio of fresh to digested organic matter evaluated by the "loss on ignition" test, was approximately 2 to 1. The characteristics of the sludges used are indicated in the following table:

	Per Cent Solids	Per Cent Loss on Ignition	pH
Fresh solids	5.3	85.6	5.4
Digested solids	15.7	29.3	6.7
Mixture	6.6	51.9	6.1

The fresh solids employed were obtained from the primary sedimentation tanks of the Brockton (Mass.) sewage-works. They represent an accumulation of solids in from 7 to 10 days. The digested solids were collected from the Imhoff tanks at Fitchburg, Mass.

Five samples of mixed sludge were incubated at 20 deg. C. ± 1 deg. under the following conditions of pH control: (Series VII of the Harvard Experiments) (1) pH uncontrolled; (2) pH held at 6.8; (3) pH held at 7.2; (4) pH held at 7.6; (5) pH raised initially to 8.0 with no subsequent pH adjustment.

The adjusting chemicals used were chemically pure hydrate of lime and dilute sulphuric acid. The gas produced by the sludge was measured daily and analyzed at 4- to 5-day intervals to determine its percentage content of CO_2 and combustible gas. The latter was recorded as methane since this seemed to be the major or sole constituent. Since the gas was collected over water probably as much as 30 per cent of the CO_2 generated was taken into solution by the water. The addition of adjusting alkalis also removed part of the CO_2. For this reason results are discussed on the basis of methane production rather than total gas production.

Determinations of hydrogen-ion concentration were made almost daily by means of a LaMotte 3B testing set which seems well adapted for determining the pH of small quantities of turbid materials. Adjustment was made whenever the pH deviated from the standard at which it was to be kept. In samples 4 and 5 (pH 7.6 and initial pH 8.0) lime only was used to adjust the reaction; in samples 2 and 3 (pH 6.8 and 7.2) both lime and sulphuric acid were used. In the former lime was added during the first week, after which adjustment to 6.8 was effected by the addition of sulphuric acid. In the latter lime was used up to the seventh week, after which sulphuric acid had to be employed.

Experimental Results—The characteristics of digestion of samples 1 (uncontrolled) and 5 (initial pH 8.0) have been shown in Figs. 1 and 2. They are exemplary of pH uncontrolled and pH controlled digestion. The corresponding curves of rate of gasification and gas composition for samples 2 to 4 (pH 6.8, 7.2, and 7.6), all of which were pH controlled, are similar to those of Fig. 2, the numerical values of course being somewhat different. The CH_4 content of the gas produced by sample 4 (pH 7.6) was abnormally high because of the removal of CO_2 by the fairly large amount of lime that had to be added.

A graphical analysis of the results obtained under the various conditions of pH control is presented in Fig. 4. Total methane production in liters per kilogram of fresh volatile (organic) solids is made the basis for comparison. The slope of the curves is a measure of the rate of gasification at any particular time. The wide diversion of the curves of uncontrolled and controlled digestion illustrates very clearly the important relation between

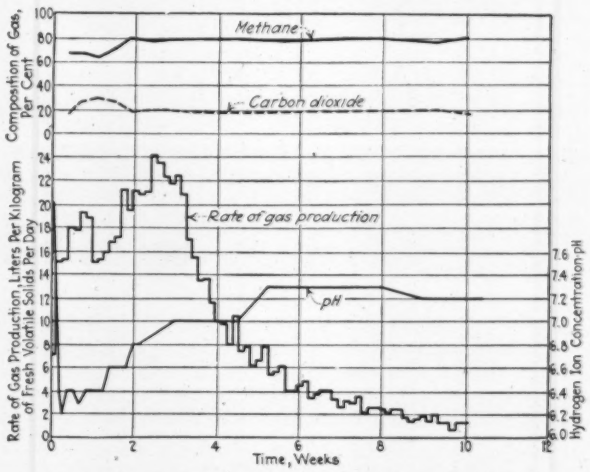


FIG. 2—CHARACTERISTICS OF CONTROLLED SLUDGE DIGESTION
pH raised with lime to 8.0 at the start, no further adjustment being made.

hydrogen-ion concentration of the sludge and the rapidity of digestion as measured by methane production. At the end of 10 weeks the methane given off by the adjusted mixtures was from 2.5 to 3.2 times that evolved in uncontrolled digestion.

Within the range of controlled pH studied in these experiments there is a tendency during the earlier weeks of digestion for the lower pH values to induce greater activity than the higher ones. At the end of four weeks the sludges held at pH 6.8 and 7.2 and the sludge given an initial high pH have produced an

equal amount of methane, namely 376 liters. After that the order of these three sludges is reversed and the sludge with initial high pH attains precedence over all others. The sludge held at pH 7.6 lags behind the other three controlled sludges for a long time and only passes that held at 6.8 during the eighth week. After four weeks it has produced 272 liters. While this is considerably less than the amounts produced by the other controlled sludges it compares favorably with the uncontrolled sludge which at that time has only evolved 76 liters of methane. The total amounts of methane in l/kg of fresh volatile matter produced at the end of 10 weeks are as follows: (1) pH uncontrolled, 157; (2) pH held at 6.8, 431; (3) pH held at 7.2, 477; (4) pH held at 7.6, 441; (5) initial high pH, 508. At the end of this time digestion of all controlled sludges was approaching exhaustion, as evidenced by the flattening out of the curves of methane production.

When drawn onto a sand filter the controlled sludges drained well. With exception of the sludge adjusted to pH 6.8 they were inoffensive in odor and gave every evidence of being in a condition in which they could be readily disposed of without creating a nuisance. The sludge held at pH 6.8 had a strong hydrogen sulphide odor caused by the addition of sulphuric acid. During digestion a considerable quantity of H_2S was produced and the mixture became deep black in color. After draining, this sludge lost its odor. The uncontrolled sludge, at the end of 10 weeks, still remained putrid.

The reduction in total and organic solids in the controlled sludges obtained at the end of 10 weeks averaged 20 per cent and 40 per cent respectively and did not deviate appreciably from the mean in the different samples. The peak rates of methane production reached by the various samples compare as follows: The highest rate was attained by the sludge held at pH 6.8; it amounted to 22.0 l/kg of fresh volatile solids and occurred in the second week of digestion. The second highest rate was 18.9 l/kg and was produced during the third week of digestion by the sludge given an initial high pH; the reaction at this time was pH 6.9. The peak rates of the sludges held at pH 7.2 and 7.6 were 17.8 l/kg and 11.9 l/kg and occurred in the second and fourth weeks respectively.

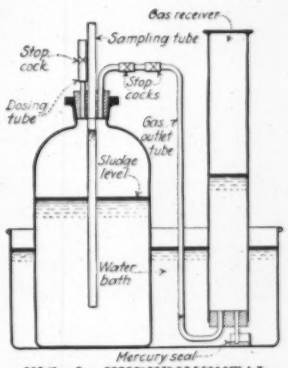


FIG. 3—EXPERIMENTAL APPARATUS EMPLOYED

Discussion—A study of the experimental results here presented shows that digestion is greatly accelerated within pH range 6.8 to 7.6. Of the three samples kept as close as experimentally possible to a definite pH, that measuring 7.2 in general held the most favorable course although initially lagging behind the pH 6.8 sludge. The sludge kept at pH 7.6 at first gasified more slowly than the other two but eventually passed the pH 6.8 sludge. These results do not mean, however, that 7.2 is the optimum pH value during the whole course of digestion. The superior results during the first four weeks produced by the pH 6.8 sludge and the accelerated activity during the last six weeks of the sludge adjusted to an initial pH of 8.0 but then left to take its own course contradict such a conclusion. Furthermore, it must be remembered that during its period of greatest methane production the sludge with high initial pH registered a hydrogen-ion concentration of pH 6.8 to 7.0. From this it would seem

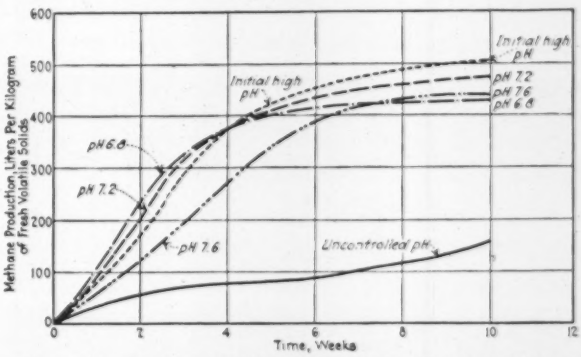


FIG. 4—COMPARISON OF METHANE PRODUCTION OF CONTROLLED AND UNCONTROLLED SLUDGES
Slope of curves shows rate of gasification.

that the optimum reaction of digesting sludge is not a constant but varies according to the stage of digestion reached by the decomposing materials at varying intervals of time. It is probable that a pH slightly below neutrality, say 6.8, is the optimum during the initial stage of digestion while one slightly above neutrality, say 7.2, becomes the optimum during the final stage of digestion. Further evidence is required before the path of optimum pH is definitely established. It may and probably does vary considerably with the nature of the sewage. Its exact definition is of great scientific interest. In the operation of present-day sludge digestion units, however, it is not possible to utilize pH control so closely as to make practical a strict adherence to the path of optimum pH. Sludge digestion would have to take the form of a "batch process" before this could be done.

The procedure of pH control suggestive of best results in plant operation would seem to be one in which a sufficient amount of suitable adjusting chemical is added to keep the pH from falling much below the initial optimum value. The self-adjusting character of marble and dolomite dust is particularly noteworthy in this connection.

It is of interest to state that the total amount of methane produced in these experiments was about 500 l/kg of fresh volatile solids, or about ½ cu.ft. per capita per day on the basis of Brockton sewage.

Public Service Association Aids Municipality

An association comprising fifty administrative heads of various operating departments of the city and public service corporations was recently organized at Springfield, Mass., and is effectively promoting a much better understanding between the various departments. Meetings are held monthly and various public utility problems discussed. Largely through this association's efforts, the duplication existing in street names in Springfield is being rapidly eliminated, and a legislative act was passed placing the control of street names in the hands of the municipality.

Modern Pyramids— Can We Build Them?

An Engineering Analysis of the Chief Requirements in Materials and Design to Erect Imperishable Structures

By David C. Coyle
Gunvald Aus Co., Consulting Engineers, New York City

WHEN the first pyramid was completed, His Majesty the Pharaoh looked at it, and said to himself, "There, I reckon that will stand for a right smart while." His reckoning was correct, and during the centuries when people cared very little for the Pharaohs, their monuments stood unmoved, awaiting an age that would honor them again.

Which of our own buildings will be standing six thousand years hence, when all the present civilization is as far from men's thoughts as that of early Egypt is at the present time? The desire to erect a monument more enduring than brass is part of our mental equipment as it was of Pharaoh's. It is related to the artistic impulses, and, in fact, in the engineering type of mind this is the form which the artistic impulse normally assumes. It may well be that the men of six thousand years hence will look back with some disdain at our barbaric desire to write our names on the landscape. But there is no use in pretending to be anything else than what we are, and if our civilization is barbaric and magnificent, it is quite proper for us to want to leave our characteristic marks for posterity to look at.

Imperishable Materials—What constitutes a monument depends a lot on the length of the future. Perishable materials will last for centuries, if they are cared for and protected, but a true monument is independent of the continuance of a civilization which will protect it and keep it in repair. What, then, are the materials whose life is independent of yearly inspection and care? First, of course, is stone—granite and other hard igneous stones for frosty climates, and limestone and marble for warmer zones. Then comes brick, hard and sound, laid in cement mortar. Third is concrete, although we do not yet know whether portland cement is as enduring as the old-fashioned natural cement, and certainly along the seashore portland cement concrete is a doubtful material if one is aiming at 3000 A.D. Of the metals, bronze for ties and lead for waterproofing are suitable. This about completes the list of materials that will stand the weather for an unknown length of time. Indoors, in any location where water will never reach it there is a place for terra-cotta, but, outdoors it is only permanent in a warm climate. So if we wish to build for the long future, we must be governed by the available refractory materials.

We are not, of course, limited completely to the use of permanent materials. The Greeks used wooden roofs, and their temples might have persisted unblemished to this day, long after the roofs had fallen in, had it not been for wars and vandalism. We are free to use plaster and paint, steel and wood, and still call our structures monumental, provided the essential character of the building is not dependent on these ephemeral additions. And although, we cannot be quite so carefree about roofs as were the Greeks, because of the prevalence of weather in our climate, we can build as they did, for all time, and then decorate for our own generation.

Fortunately for our reputation with posterity, we, like the ancients, are not in a position to do too much permanent building. What we construct for the sake of dividends must necessarily be in large part ephemeral; our successors will eventually replace our work by structures in accord with their newer ideas. Even our public buildings, if left to the jungle for a few hundred years, will show a considerable mortality.

The Structure—From the engineering standpoint, a structure that might last for several thousand years would be expensive for its size, and if it were particularly large, it would be very expensive indeed. Structurally it must be of stone. The weight would be large, and the foundation must rest on sound rock not liable to quakes nor to submergence in the sea. The climate preferably should be less violent than that of New York.

A Double Cylindrical Building—The simplest acceptable design might be a double hollow cylinder, with a large court inside and with the two shells close enough together to carry permanent floors. A permanent floor, though, is rather limited in its possible applications. For short spans, there is the Egyptian style of stone slabs and beams. Slightly longer spans could be made in adhesive masonry, and small quantities of long span work, with bronze reinforcement, might be used. Vaulting would be possible in a double cylinder, but the thrust would either have to be carried by bronze rings or by tensile bonding in the ring wall. The latter is not a new factor in masonry, a number of the ancient domes having no other visible means of support, but it has the disadvantage that a rather light earthquake will throw it down.

Conical or Pyramidal Building—To avoid this difficulty, we may resort to the hollow cone or pyramid, shaped like an ordinary church spire, or modified toward the beehive or the pagoda form. Such a structure, with the lower part of the granite ashlar, might go as high as 1,000 ft. It could have domed floors, the thrust of which would be carried by the ring compression of the conical wall, and finally transmitted as an oblique reaction to the rock below. At the base, it might be possible to carry the superstructure on an immense domed hall, or on a ring of arches with a domed interior ceiling, suitably buttressed on the outside. The exterior of the tower could be terraced with colonnades, if desired, so long as the carrying cone was allowed to run undisturbed from top to bottom.

Within the structure, less permanent work could be built, as a sort of furniture, to make it habitable. Elevators could run up the slope of the cone. Steel floors and galleries could be built in. Even plumbing would be safe, since its leaking would not affect the main structural members. The roofs or decks would be waterproofed with copper or lead, and paved if desired, while the interior floors, of stone or glass slabs, would be carried on terra-cotta spur walls from the domed ceilings. In well-protected locations, steel bands could be built into the walls to serve for as long as they might endure, as a protection against earthquakes.

Large Domed Structures—So much for the vision of a twentieth century monument to scrape the sky after our characteristic manner. The other and much less expensive way to attain bigness is by spreading out over the ground. We are now prepared to attempt domes of a size beyond the capacity of the old builders who were innocent of integral calculus. All domes, however, have one ticklish characteristic, in that they require a tension ring somewhere, to keep them from splitting open around

the bottom. The shape can be modified so as to move this tension ring up or down, but it can never be eliminated. The worst sort of dome is the bulbous form, common in the near East, which will inevitably split open at the level of its greatest diameter, unless it is strong enough to stand the tension. Bonded masonry has a considerable but uncertain tensile strength, and it is probable that a good many bulbous domes stand up by virtue of this fact, and without metallic rings. However, a position under one of these domes is not one an engineer would choose to occupy during an earthquake.

The ordinary spherical or conoidal dome, which appears on so many of our public buildings, is next in instability to the bulb. It has a tensile area beginning about 45 deg. from the top, and increasing down to the springing line. We, now, insert rings in this part of the dome, which will make it safe so long as the steel resists corrosion, but the early builders were apt to depend on ignorance or on the tensile strength of the masonry. In the case of St. Peter's Cathedral in Rome, a chain was added when the masonry began to crack.

There are three forms of a dome which do not have tension in the dome shell—a rounded dome of low rise, a cone and a concave conoid or pagoda form. A rounded dome of low rise is the equivalent of an ordinary dome with its lower, tensile, part cut off; it has only compression in all directions. The latter is true also of the cone, and of the concave conoid form. In all there is a tension ring at the springing only.

For monumental construction, designed to outlast the life of steel, one may treat a dome in two ways. One is to use hard bronze instead of steel. The other is to use buttresses to carry the thrusts down to the foundation level, where the earth itself acts as a tension ring for the whole structure. By either of these devices, we can now build a structure that will exceed, in size, anything our predecessors have done, and that will, at the same time, be permanent in the monumental sense.

These, then, are the directions in which we may look for our opportunity to leave an enduring record of our passage. Such an enterprise is fantastic, as fantastic as the pyramids; but, too, our civilization is no less fantastic than that of the Egyptians. When we in turn have passed on, leaving a detritus of gold coins and broken glassware, and a few comparatively uninteresting tombs, there will also be among our legacies some engineering feats worthy to rank with those of other civilizations. Dams, canals, and tunnels, we have already. It would not be inconsistent with our prodigal vitality and our unprecedented control of power, if we were to add a few tremendous architectural monuments to the list.

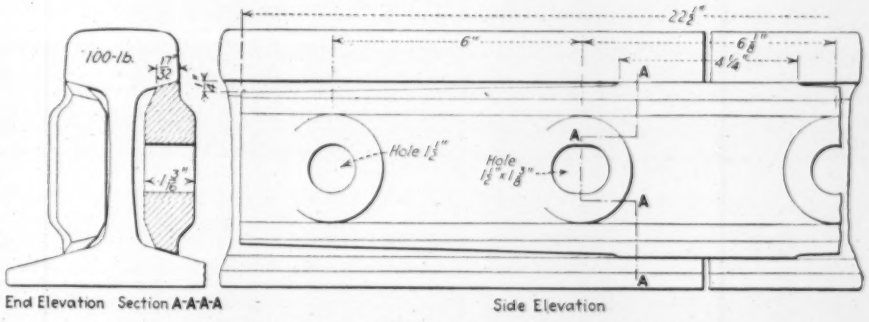
New High Record for Panama Canal Traffic

In October, 1927, a new high record was set for traffic through the Panama Canal, according to figures from the *Panama Canal Record*. The number of transits, 567, exceeded by 24 the previous record of 543 in August, 1927. Tonnage of 2,585,752, exceeded by 69,261 and tolls of $2,380,115 by $44,386 the previous records, Dec., 1923.

Rail Joint Forms Hinge in Wave Motion

AS A result of some years of successful experimental service on the St. Louis Southwestern Ry. and other lines, a rail joint which is designed to provide more effectively for the wave motion in rails and also for resistance to lateral motion is now being introduced on a commercial basis. Trial orders have been placed by several railroads, mainly for rails of 70 to 100-lb. section, but at least one road will apply it also to 56-lb. rails, with a view to determining its advantages for light track on branch lines. The reason in this case is the claim for material reduction in track maintenance work and expense. This joint is the invention of H. F. Roach, of the Reinforced Rail Joint Co., St. Louis, Mo. It is being manufactured and put on the market, under the name of A-C-F Roach joint, by the American Car & Foundry Co., Chicago and St. Louis.

The design of this joint, shown in the accompanying drawing as applied to a 100-lb. rail of the A.R.E.A. section, has a distinctive feature in giving contact surfaces only 4¼ in. long between the splice bars and the head and base of rails, the end portions of the bar being tapered at top and bottom so as to be clear of the rail. Furthermore, the bars are bent or sprung longitudinally, so that while the middle portion is free from the rail web (as in most rail joints), the ends are in contact with the web and are held against it by the bolts. The original design was illustrated in *Engineering News-Record*, Oct. 22, 1924, p. 537.



ROACH RAIL JOINT, WITH SHORT CONTACT SURFACES

The bars are only 22½ in. long, with four bolts, and are of the plain or fish-plate type, without angle or flange. They are of open-hearth steel, first rolled to approximate section, then die-sheared, die-forged and punched in one operation, in one heat, at a temperature of approximately 100 deg. F. above the upper critical temperature of the steel used. After forging, the bars are allowed to cool to about 100 deg. F. less than the upper critical temperature of the steel, and are then uniformly reheated to a temperature of approximately 50 deg. above the upper critical temperature, and then allowed to cool in the air. In the bend test, which is similar to that for ordinary angle-bars, the specimen must bend cold through 90 deg. around a pin whose diameter is equal to three times the thickness of the specimen, without cracking on the outside of the bent portion.

With the short contact surfaces, the rail ends are free to deflect in the wave motion under passing loads, but at the same time both rail ends must deflect uniformly. The action is to some extent that of a hinge joint. No vertical load is transmitted through the ends of the bars, since they are free from the rail, and the bolts are con-

sequently relieved from stresses ordinarily sustained. In fact, it is claimed that the joint acts mainly in shear, with only a small bending moment. It is further claimed that with free deflection, unhampered by long contact surfaces, any tendency toward anvil action of the rail heads on the splice bars is eliminated, with consequent reduction in battering of rail ends and low spots in track.

For insulated joints the construction is very similar, but the bars are only 19½ in. long. Channel-shaped strips of insulating material are fitted between the bars and the heads and webs of the rails. Insulating bushings are placed on the bolts and washers between the steel spring washers and the bars. The ordinary fiber end post is placed between the rail ends. Both insulated and ordinary joints are included in the present orders, which aggregate several thousand rail joints.

Production and Profit Coincident on Road Work

All Profits Come from Production and Materials; Other Job Costs Merely Help to Save or Waste Profits

By J. L. Harrison
Highway Engineer, Bureau of Public Roads, Washington

Besides overhead, bonds, and insurance, which are costs separate and apart from handling the job itself, there are incident to construction the costs of (1) Getting equipment and men onto the job and getting organized —creating a going organization; (2) production, which includes labor, equipment depreciation, equipment repairs, operation of equipment, etc.—all labor and equipment costs arising from production operations; (3) materials (when used); (4) weather losses; and (5) getting equipment off the job, work cleaned up and accepted—closing operations.

Items 1, 4, and 5—creating a going organization, weather losses, and closing operations—are a dead expense. They are, it is true, a necessary part of the whole operation of building a pavement, but they can in no way create profit. All profit comes from items 2 and 3—production and materials. It follows that the contractor for highway work has two aspects of profit to consider: (1) the gross profit which is the difference between production cost plus materials and selling price, and (2) net profit, which is gross profit minus the cost of creating a going organization plus weather losses plus the cost of closing operations.

Any practice which reduces the cost of creating a going organization will improve net profit, for it reduces the amount withdrawn from gross profit. The same may be said as to the effect of reducing the cost of closing operations. Whatever is spent here is a dead expense which acts directly to reduce net profit. Expenses of this nature are peculiarly destructive of profit for in essence they are wholly paid out of funds that otherwise would be available for profit. Efforts to reduce costs in these fields are, therefore, perhaps the most easily and the most directly successful in improving net profit. But beside the matter of reducing the direct draft on gross profit, there is in practically all highway work the possibility of improving gross profit.

Laying a concrete pavement, C, the unit production cost, equals X/Y, in which X is the cost of operation during a specific unit of time (generally one day) and Y is the production during the same unit of time. Unit production cost may be improved either by reducing X, the daily cost of operation, or by increasing Y, the production.

Extended field observation has shown that the daily cost of operation is approximately constant. The payroll is governed pretty rigidly by the equipment used. The depreciation as well as operating expenses are affected very little by the rate of output. On concrete paving jobs the daily cost generated by these items—payroll, depreciation, repairs, operating charges, etc.—generally amounts to some $400 a day. This amount naturally varies somewhat with regional differences in wage scale, with the methods used, with the style and amount of equipment employed, etc., so it is not to be viewed as a fixed figure. It is, however, a safe average figure.

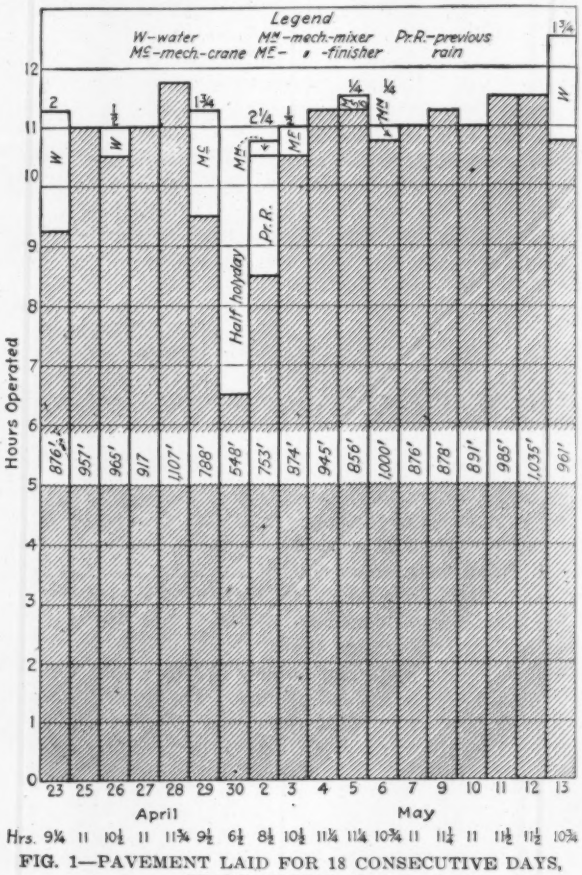


FIG. 1—PAVEMENT LAID FOR 18 CONSECUTIVE DAYS, SPARTANBURG, S. C.

Total of 20-ft. pavement 16,212 ft.; equivalent 18-ft. pavement, 18,760 ft., or 1,042 ft. per day. Note delays and their causes. Pennell & Hartley, Contractors.

A more important matter is the fact that once the equipment is selected and the methods of operation are chosen the daily cost for a specific job is rather definitely fixed and is likely to remain so during the course of the job. There will be a little fluctuation in daily payroll and repairs naturally cost more on some days than on others, but even after admitting all of the minor variations which can be pointed out, it remains more nearly accurate to consider the daily cost on a paving job as constant than to view it in any other way.

But if the cost per day, X, is constant, and this is a

DAILY PRODUCTION RECORD OF 18-FT. CONCRETE PAVEMENT BY McGUIRE & CAVANDER, IN BOWIE COUNTY, TEXAS

Date, 1926	Length, Ft.	Remarks	Hours Mixing	Hours Delay: Rain and Wet Grade	Hauling Eqpt.	Mixer and Eqpt. Trouble	Water	Forms	Miscel.	Total Hours
September 20	1,016	Fair	9:45	....	....	0:30	....	0:15	....	10:30
21	1,172	Fair	11:00	....	....	.....	.....	.....	.....	11:00
22	867	Fair	9:40	0:40	0:10	.....	0:30	.....	.....	11:00
23	.....	Cldy. Eqpt.	.....	.....	.....	.....	.....	.....	.....	.....
24	1,067	Cldy. Eqpt.	10:30	.....	.....	0:10	0:10	0:20	.....	11:10
25	1,015	Cldy. Eqpt.	10:20	.....	0:35	.....	0:05	.....	.....	11:00
Sunday 26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	648	Cldy. Eqpt.	6:35	.....	.....	2:40	0:45	.....	.....	10:00
28	958	Cldy. Eqpt.	9:35	.....	.....	0:45	0:10	.....	.....	10:30
29	976	Fair	10:50	.....	.....	0:10	.....	.....	.....	11:00
30	859	Fair	9:10	.....	.....	0:35	1:15	.....	.....	11:00
October 1	909	Fair	10:00	.....	0:40	0:40	0:10	.....	.....	11:30
2	873	Fair	9:45	.....	.....	.....	0:15	.....	.....	10:00
Sunday 3	.....	Showers	.....	.....	.....	.....	.....	.....	.....	.....
4	.....	Fair, Wet Grade	.....	.....	.....	.....	.....	.....	.....	.....
5	1,117	Fair	10:35	.....	.....	.....	0:25	.....	.....	11:00
6	1,142	Fair	9:35	.....	.....	.....	0:05	.....	0:50	10:30
7	1,331	Fair	11:40	.....	0:05	0:15	.....	.....	.....	12:00
8	970	Fair	9:14	.....	0:10	0:10	0:26	.....	.....	10:00
9	721	Fair	6:43	.....	1:40	0:37	.....	.....	.....	9:00
Sunday 10	.....	Rain	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	Rain*	.....	.....	.....	.....	.....	.....	.....	.....
12	.....	Fair	.....	.....	.....	.....	.....	.....	.....	.....
13	.....	Fair	.....	.....	.....	.....	.....	.....	.....	.....
14	.....	Fair	.....	.....	.....	.....	.....	.....	.....	.....
15	.....	Fair	.....	.....	.....	.....	.....	.....	.....	.....
16	.....	Fair	.....	.....	.....	.....	.....	.....	.....	.....
Sunday 17	.....	Fair	.....	.....	.....	.....	.....	.....	.....	.....
18	.....	Fair	10:00	.....	.....	0:10	0:50	.....	.....	11:00
19	994	Fair	9:05	.....	.....	1:45	0:10	.....	.....	11:00
20	.....	Fair	Repr. Mixer	.....	.....	.....	.....	.....	.....	.....
21	1,165	Fair	10:20	.....	.....	.....	0:10	.....	.....	10:30
22	1,030	Fair Eqpt.	9:20	.....	.....	0:25	0:15	.....	.....	10:00
23	.....	Fair Eqpt.	.....	.....	.....	.....	.....	.....	.....	.....
Sunday 24	.....	Fair	.....	.....	.....	.....	.....	.....	.....	.....
25	963	Fair	9:20	.....	.....	1:35	0:15	.....	.....	11:10
26	691	Fair	6:20	.....	.....	4:30	.....	.....	0:10	11:00
27	1,115	Fair	10:10	.....	.....	.....	0:20	.....	.....	10:30
28	844	Fair	8:05	.....	.....	2:10	0:10	.....	.....	10:25
Total	22,443		227:37	0:40	3:20	17:07	6:26	0:35	1:00	256:45

Total for whole job, 53,145 ft. of pavement laid in 522½ working hours; average production 101.7 ft. per hour.

* Fill between mixer and plant washed out approximately 300 ft. This time lost replacing fill.

reasonable statement of the condition as most contractors find it, it naturally follows that the unit cost, C, will fall as Y, the production, rises. To convert these facts into practical terms, if the daily cost of production is $400 and the yardage produced per day is 1,000 it naturally results that: $C = \frac{400}{1,000}$ or 40c. per square yard. If production is 2,000 square yards a day, $C = \frac{400}{2,000}$ or 20c. a square yard. But there are over 10,000 sq.yd. in a mile of standard 18-ft. concrete pavement. Therefore, the contractor who can produce at the rate of 2,000 sq.yd. a day has an advantage of over $2,000 per mile in the production cost at which his work is accomplished as compared with the contractor who is producing at a rate of 1,000 sq.yd. a day which appears to be about the rate at which most concrete paving work is done.

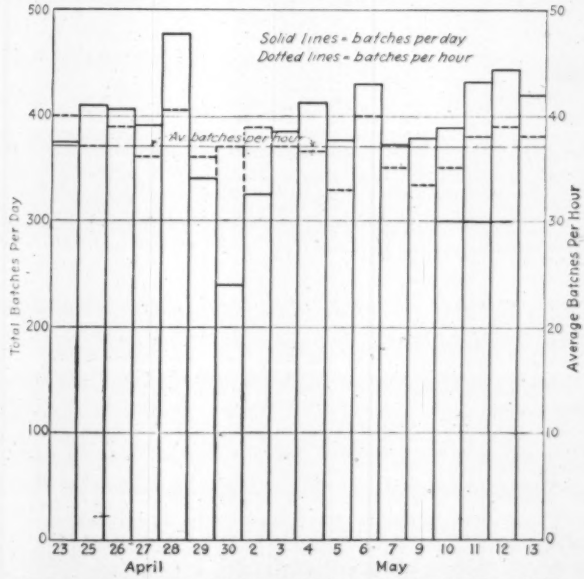


FIG. 2—BATCHES MIXED FOR 18 CONSECUTIVE DAYS, SPARTANBURG, S. C.
Pavement 8-6½-8 in., 20 ft. wide; 1½-minute mixing time.

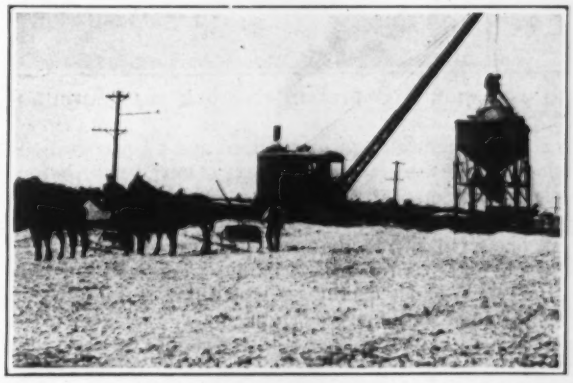


FIG. 3—SALVAGING MATERIAL AS WORK FROM SETUP NEARED COMPLETION, SPARTANBURG
Note teams and fresno scrapers cleaning up stock pile site.

But gross profit is selling price less production cost plus material cost, so if production cost is reduced $2,000 a mile, gross profit is increased by this amount. Naturally, net profit is equally increased if only ordinary care is exercised in the matter of creating a going organization and closing operations. However, the man who is efficient in one department is apt to be efficient in all, so it appears generally to be true that costs are also reduced here. Commonly, weather losses are reduced automatically as the high production job is finished so quickly that weather losses are reduced to the minimum.

That high production can be and as a matter of fact is

being attained, the accompanying figures which are actual results secured by two outstandingly successful contractors is apparent. Not much need be said as to the accomplishments reported in these tables, except that with an ordinary crew, standard equipment, and the usual methods of operation, these firms are able by working at a high hourly rate and utilizing a high percentage of their working time, to secure very high average daily rates of production.

The equipments used by Pennell & Harley on the Spartanburg job and by McGuire & Cavander at Texarkana follow the same general lines: Material yard, crawler type crane and standard weighing or volumetric batching devices; mixer, standard six-bag machine; transportation, on one job, single-batch trucks, on the other, two-batch trucks; finishing, mechanical, and subgrade, subgrader and roller. On both jobs the usual equipment of steel, forms, pipe lines, pumps, hand tools, special finishing tools, etc., were used.

As a special precaution to insure speed in operation, Pennell & Harley use a second crane and a second hopper so that materials can be received and all preparations made to begin work out of the next material yard before work is completed at the last site occupied. This practice avoids the delays so often encountered in moving from one yard site to the next, and does this at a very reasonable cost as the second crane is operated for only short periods under conditions which make it possible to use a machine too nearly worn out to be satisfactory for steady operation on a fast job. McGuire & Cavander also protected operation by advance stock piling on the job from which the figures in the table were obtained.

FIG. 4—A GROUP OF FINISHING TOOLS, SPARTANBURG

The reference to these outstandingly fast jobs and their significance from a cost standpoint would not be complete without noting the fact that the high rate of production in no way interfered with the quality of the work done. In fact, the quality of the concrete secured on the Texarkana job is unusually high and the surface finish fully up to ordinary modern standards, while on the Spartanburg job the surface finish is of such outstanding quality as to be notable. These facts are referred to because they show that there is no real conflict between quantity in production and quality in production. There is, therefore, nothing to be lost by fast operation while the contractor who attains it can feel certain of a real profit even when the man who attains only average production has no profit at all!

These two jobs appear to justify two conclusions: (1) that at the prices now being bid on concrete paving work, while there is not likely to be much profit unless a high rate of production is maintained, a reasonable profit can be had if a satisfactory rate of production is maintained; (2) as, under prevailing prices for concrete pavement, a profit can ordinarily be had only when high production is secured, and as there is no actual conflict between a high rate of production and a high degree of quality, business considerations dictate that in the legitimate protection of quality through inspection, every effort should be made to protect and support production.

Additional New England Rainfall Records

RAINFALL on Nov. 2 to 4 at many points in and near the New England flood area, as reported to the U. S. Weather Bureau, are given in the accompanying table. These figures supplement the table in the article by Prof. H. K. Barrows, in *Engineering News-Record*, Nov. 17, 1927, p. 797. A few stations are repeated, with a second figure in parenthesis, the latter being an earlier and different figure given in Prof. Barrows' paper. A second table gives hourly rainfalls at Concord, N. H., reported by E. G. Vose, meteorologist, U. S. Weather Bureau at Concord.

RAINFALL AT POINTS IN AND NEAR THE NEW ENGLAND FLOOD AREA NOV. 2-4

From returns to the U. S. Weather Bureau

	Inches
Maine	
Presque Isle	2.46
Van Buren	1.89
Portland	0.76 (0.75)
Bar Harbor	1.95
Old Town	2.31
Gardiner	1.68
Winslow	1.56
Greenville	3.38
Rumford	3.81
Woodland	2.11
Eastport	3.14
Lewiston	1.44
No. Bridgton	3.54
New Hampshire	
Concord	5.43 (4.12)
Lincoln	5.04 (4.5±)
Plymouth	5.30 (6.13)
Lake Winnepesaukee	4.06
Garvens Falls	4.19
Greggs Falls	4.60
Manchester	2.90
Nashua	4.07
Merrymeeting Lake	4.08
Vermont	
Bellows Falls	4.49
Brattleboro	4.68
Massachusetts	
Haverhill	2.14
Gardner	4.09
Charlton	3.44
Warren	4.00
Westfield	4.70
Amherst	5.63 (5.75)
Turners Falls	4.46 (4.2)
Middlefield	7.00
Cummington	6.51
Williamsburg	4.55

Massachusetts—*Continued*	Inches
Plainfield	6.83
Chesterfield	6.64
Cobrain	4.69
Concord	2.84
Wollaston	2.10
Fall River	2.26
Attleboro	2.25
Barre	4.65
Athol	5.22
Ware	4.37
Groton	6.70
Webster	3.92
Lakeville	2.91
Chester	7.70
Provincetown	1.40
Nantucket	1.55
Haverhill	2.28
Southbridge	3.87
Huntington	6.28
Nettleboro	2.70
North Dana	4.33
Wendall	5.91
Greenwich	4.34
Norwood	2.33
Greenfield	5.06
Littleton	3.92
Rhode Island	
Block Island	2.87
Connecticut	
Hartford	3.58 (3.57)*
New Haven	
North Grosvenor Dale	4.28
Bridgeport	3.84
Colchester	4.23
Waterbury	5.13
Norwalk	3.57
W. Cornall	5.35 (5.82)

*C. M. Saville, manager and chief engineer, Hartford water-works, reports 3.98 in. for the West Hartford watershed, 6 mi. west of Hartford, 6.14 in. for the Nepaug, 18 mi. from Hartford and about 1½ mi. northwest of Collinsville, in the town of Canton, and 6.76 for the East Branch reservoir, 22 mi. from Hartford about 1 mi. east of the village of New Hartford, on the East Branch of the Farmington River.

HOURLY RAINFALL, CONCORD, N. H., NOV. 3-4, 1927

Nov. 3, P.M.	Inches
9-10	0.12
10-11	0.44
11-12	0.88
	1.44
Nov. 4, A.M.	
12-1	0.57
1-2	1.14
2-3	0.51

Nov. 4—*Continued*	Inches
3-4	1.13
4-5	0.45
5-6	0.42
6-7	0.05
7-8	0.04
	4.31
Total	5.75

Emergency Water Supply Relief in New England's Flood Area

Chlorinating Apparatus and Supplies Rushed to All Municipalities that Were Liable to Suffer Impairment

THROUGH the co-operation of the State Board of Health, the U. S. Public Health Service and Wallace & Tiernan Co., the sanitary services and water supplies of Vermont cities and towns have quickly been restored to safe use after the worst and flashiest flood the streams of that state have known, at least since 1869. Hampered for the first two days through the crippling of practically all means of communication, these agencies have been working day and night to safeguard the health of the badly affected and widely-separated communities. The chronology of events which led to the restoration of water supply in Waterbury, Vt., is herewith given. That village with about 3,000 inhabitants, including more than 1,000 inmates of the State Asylum for the Insane, is taken as a typical example of emergency and final relief. It was perhaps the hardest hit of any village in the valleys of the Missisquoi, Lamoille and Winooski rivers, and in that community the State Board of Health and the U. S. Public Health Service concentrated their efforts.

Relief Action—Before giving details, a short outline of the general sanitary conditions of the state's towns and villages should be given. Practically all of these communities that were affected by the flood get their water supplies by gravity from mountain springs and streams. Only three to which assistance was given chlorinated their water supplies—Rutland, Montpelier and Sheldon Springs—and none had filters. Cast-iron pipe from 4 to 8 in. in diameter served both for collection and distribution in the smaller communities. Sewage was discharged by gravity, without treatment, into flooded streams.

When the floods began to subside the Vermont State Board of Health attempted a check-up on municipal sanitary conditions. But telephone, telegraph, highway and railroad communications were badly impaired if not entirely put out of commission. Reports, however, began to filter in, and at the same time came offers of assistance—from the U. S. Public Health Service, the sanitary engineering divisions of the state departments of health of Maine, New Hampshire, Massachusetts, Connecticut and New York, and from Wallace & Tiernan Co., New York City. The Vermont State Board of Health on Nov. 6 availed itself of several of these offers and through Prof. J. W. Votey, in charge of sanitary engineering, and Dr. Charles F. Dalton, secretary of the board, accepted the offers of the New York State Department of Health to furnish typhoid vaccine and expedite shipments of calcium hypochlorite, the U. S. Public Health Service for sanitary engineering assistance (this was furnished in the person of E. C. Sullivan, technical assistant in sanitary engineering).

Upon telegraphic request Wallace & Tiernan loaded a truck of chlorinating equipment in Newark, N. J., after assembling and testing all the apparatus, and left that city at 10:30 p.m. Sunday, Nov. 6. Their district manager, G. H. Pratt, with five other men from the organization, drove all night to reach Port Kent, N. Y., on the western bank of Lake Champlain opposite Burlington, at 3 p.m. Monday. The distance is 350 miles by automobile. Ferry service, discontinued late in October, was resumed for the flood emergency and eight complete units of chlorinating apparatus, equipped for adaptation to any hydraulic condition, six 100-lb. cylinders of chlorine, and six 20-lb. tanks were loaded in Burlington that evening. Previous to this time, all affected communities that could be reached had been warned to boil water until damaged municipal water supplies could be restored to safe conditions.

Mr. Cashmore, with Wallace & Tiernan men, reached Waterbury Tuesday evening, Nov. 8, having to detour through the mountains 60 miles to reach that place, only 28 miles up the river from Burlington. Wednesday morning a chlorinator was set up at the gate house of the collecting basin pending repairs on the supply system. Two breaks were found in the system, permittng the possible introduction of polluted water, and these had been repaired by Tuesday by local forces. Mr. Sullivan, of the U. S. Public Health Service, arrived in Waterbury Wednesday evening. Working with Dr. F. S. Kent, director of the division of communicable diseases of the Vermont Board of Health, who was that board's representative in Waterbury, a survey was made of the sanitary services and steps were taken to return them to safe public use.

By noon, Nov. 10, the water was turned into the system, a chlorinator put in use with a heavy disinfecting dosage. Pressure was developed late in the afternoon. That night an equalizing reservoir into which the little-used night supply was backed up through the distribution system for emergency fire use, was investigated and disinfected. An auxiliary supply to this reservoir was diverted as being questionably sanitary.

On Nov. 11, after allowing heavily disinfected water to remain in the distribution system overnight, it was flushed and the chlorine dosage reduced to the normal excess. The next day, Nov. 12, the supply was open to public use and a strict quarantine put on bringing any other water into the town. Notices were posted throughout the town to the effect that the village supply alone should be used. Chlorination will continue until bacterial analyses demonstrate that the treatment is no longer necessary.

Sewerage facilities have been little impaired in any of the affected areas. Waterbury was practically the only community where army latrines were dug and these were discarded when the water supply was again put into commission. Lack of flushing water was the only reason why the sewers could not be used immediately after the flood.

Other Cities—While conditions at Waterbury were being restored, men from the State Board of Health and from Wallace & Tiernan were pushing on to other localities. Chlorinating apparatus went with them to install if conditions were found necessary. Water supplies were checked at St. Johnsbury, on the Passumpsic River; Hardwick and Johnson, on the Lamoille; Barre and Montpelier on the Winooski (in addition to the work at Waterbury, already described); Rutland, Proctor and Middlebury, going north on Otter Creek; and at Ludlow on Black Creek in southeastern Vermont.

As a result of this quick action it is believed that epidemics were prevented unless caused by the use of contaminated water before it was possible to send treatment apparatus to afflicted areas.

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Six Counties to Have Hearings—First Testimony Indicates Probable Cost as Prohibitive

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County Figures Presented

In opposition to these figures taxpayers of Sonoma County presented a report prepared by J. B. Pope, Charles B. Wing and W. J. H. Fogelstrom, consulting engineers, who had been retained to estimate (1) the cost of bridge and approaches; (2) the revenue that could be expected from tolls and (3) the amount of money that would have to be raised by taxation to carry out the project. The report prepared by this board comprises 66 pages, including charts, diagrams, tables, etc., supporting the conclusion that proponents have estimated the cost of the bridge at less than one quarter the minimum probable cost, which the board places at $112,000,000. The following has been taken from the report.

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Although the report upholds the permit and is a victory for the Chicago Sanitary District, assuming that the Supreme Court adopts Mr. Hughes' recommendations, it is equally uncompromising in holding that the permit is revokable at any time for cause and that the Chicago Sanitary District is absolutely dependent upon the Congress of the United States, either directly or by delegated power through the Secretary of War, for the right to divert any water whatever from Lake Michigan.

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Rulings on Facts

Mr. Hughes' report deals first with the facts and then with the law of the case. As to the effect of the diversion through the drainage canal on lake levels, Mr. Hughes says that a diversion of 8,500 sec.-ft. would lower Lake Michigan and Huron approximately 6 in. at mean lake levels and Lake Erie and Ontario approximately 5 in.

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On the broader question of improvement to navigation on the Mississippi resulting from the diversion of 8,500 sec.-ft., Mr. Hughes says that while the diversion "increases to some extent during low water the navigable depth over bars on the Mississippi River," the actual "increase is not the subject of sufficiently accurate determinations to warrant the finding."

Remedial work to offset the effect of the Chicago diversion, Mr. Hughes concludes from the evidence submitted, is practicable.

Questions of fact are concluded with a consideration of claims by the complainant that abstraction of water through the drainage canal might be reduced to zero or at least to 1,000 sec.-ft. without injury to the health of Chicago provided adequate measures were taken to treat the sewage and protect the water supply of the city. After reviewing various phases of this claim, Mr. Hughes concludes that the questions at issue "are appropriate for determination by competent administrative authorities" and that exact "findings are not necessary for the disposition of these suits." Judging from the testimony, he ventures the opinion:

If the work of sewage treatment is efficiently carried on, and is extended by the most approved methods, and additional and appropriate measures are taken for water purification, it appears to be possible largely to reduce or altogether to terminate the diversion from Lake Michigan, and still to give the city of Chicago a reasonable measure of immunity from disease through pollution of its water supply.

He holds that the underlying conditions of the permit granted by the Secretary of War on March 3, 1925, were reasonable "with respect to the measures immediately practicable"—especially on taking into account that the diversion from Lake Michigan could not be cut down to zero or even 1,000 sec.-ft. "and in consequence the sewage of the Sanitary District in its present condition turned into Lake Michigan, without exposing the inhabitants of the district to grave risk of water-borne diseases by contamination of the water supply taken from the Great Lakes."

The gist of Mr. Hughes findings of law is that the Sanitary District of Chicago has "no authority to make or continue the diversion in question without consent of the United States" and "that the permit of March 3, 1925, is valid and effective according to its requirements, the entire control of the diversion remaining with Congress." He advises that the United States Supreme Court dismiss the bill of complaints, but "without prejudice to the right of the complainants to institute suit to prevent a diversion of water from Lake Michigan in case such diversion is made or attempted without authority of law."

Mr. Hughes gives an adverse opinion as to the following five claims of the complainant states:

(1) That the diversion constitutes a taking of complainants' property without due process of law and without just compensation in violation of the Fifth Amendment; (2) that Congress could not authorize the diversion from the Great Lakes-St. Lawrence watershed to the Mississippi watershed; (3) that the authorization of the diversion would constitute a preference of the ports of one state over those of another in violation of Article 1, Section 9, Clause 6, of the Constitution; (4) that the power of Congress extends to the protection and improvement of navigation but not to its destruction or to the creation of obstructions to navigable capacity; and (5) that the diversion is for purposes of sanitation and development of power rather than of navigation and hence is outside the authority of Congress under the commerce clause.

As to claim 1, Mr. Hughes ruled that there is no "taking" in the constitutional sense because the damage will be "incidental" and is therefore not a taking of property for public use. Through administrative action, under Congressional authorization, Mr. Hughes states:

* * * Structures may be erected in the beds of navigable waters, jetties may be constructed, etc., etc., which preclude uses and improvements of property, otherwise possible and valuable, and riparian proprietors have no ground for complaint by reason of the actual, but incidental, damage thus sustained, for the reason that their ownership is subject to the servitude of the exercise of the governmental power. It is a case of *damnum absque injuria*. * * * Great States as riparian owners, as well as individuals, are subject to the authority of Congress, and they have no ownership in navigable waters which they can assert in opposition to the exercise of that authority.

As to the diversion of water from one drainage basin to another, Mr. Hughes goes so far as to say, in effect, that this is entirely within the discretion of Congress in its exercise of the "sovereign power of the nation in determining national policy."

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Acquisition of Site for Sewage-Works Is Started by the City of Detroit

In accordance with recent action by the city council of Detroit, the legal department of that city has begun proceedings to acquire a site for sewage-works in accordance with the recommendations of the engineering and other reports abstracted at length in *Engineering News-Record*, Jan. 21, 1926, p. 112. The council resolution authorizing this action was adopted unanimously, which is of interest in view of attempts made since the engineering reports were submitted to substitute some other plan for disposal and in view of the opposition of the village of River Rouge to locating the works within its area. Litigation on behalf of River Rouge is expected to be based on the so-called Darin bill passed by the last legislature prohibiting one municipality from constructing a sewage-works within the limits of another without the approval of the voters of the latter community by a majority vote at an election. It appears that such an election cannot be called except on two-thirds favorable vote of the governing body of the community desiring to block the location of sewage-works within their area. The Darin bill is statewide in its application, but apparently was put through the legislature on the initiative of River Rouge. The act in question was signed by the Governor on May 24, 1927. The proposed sewage-works include the detritus and Imhoff tanks and disinfection of the entire sewage of the city of Detroit. The consulting engineers who recommended this plan were Harrison P. Eddy, John H. Gregory, and Clarence Hubbell. John W. Reid is commissioner of public works, and Percy A. Fellows is city engineer.

Debate Golden Gate Bridge

(*Continued from p. 890*)

ties included in the assessment district.

If a 4,010-ft. span is found practicable the pier at Fort Point would have to be 940 ft. out from shore while the one at Lime Point would have to be 400 ft. from shore. Both piers would be in water 75 ft. deep and would probably have to be carried down to a depth of at least 115 ft. below high tide level. The pier locations are exposed to the heavy seas that roll in directly from the open ocean, the bottom here falls away steeply to a depth of over 300 ft., and tidal currents are as much as 9.5 ft. per second. Changes in the bottom have been noted at both pier sites, at one of which the depth has been increased 40 ft. in seven years. The caissons that would have to be sunk in these exposed locations would be 105 ft. wide in the direction of the bridge axis and 257 ft. long at right angles to it. Under these conditions, even if the borings show favorable rock formation, which surface indications suggest is unlikely, the cost of piers and anchorage would be $28,800,500. Discrepancies between the estimates of proponents and the board of engineers are particularly marked in the matter of foundations. Where the proponents allowed for 114,000 cu.yd. of concrete, the board reports that 796,046 cu.yd. would be required besides a protective facing of 63,265 cu.yd. of granite for concrete piers and anchors.

A summary of the cost estimates prepared by the board, assuming that the 4,010-ft. span is found feasible, is given in the following:

Main piers and anchors	$28,800,500
Interurban railway approaches	3,174,373
Highway approaches	429,481
Steel superstructure	43,684,895
Administrative and engineering	6,467,586
Preliminary organization and investigation	2,000,000
Interest during construction	27,787,943
Total	$112,344,778

Despite the exposed location, the extremely high towers (950 ft.) and the fact that the structure would be parallel to the San Andreas earthquake fault (which lies about 12 miles west of the site), the report points out that proponents are suggesting a bridge width 40 per cent less than that required by standard practice for lateral stability. Dead load allowances appear to have been only 12,676 lb. per linear foot, or less than one-third the dead load used in figuring the Hudson River bridge now being built, whose span is to be only 3,500 ft. This discrepancy is the more marked when it is remembered that dead load varies roughly as the square of the span. With reference to the patented combination of cantilever and suspension type of design that the proponents of the project suggest, the board concludes that it would afford no saving in cost and would probably increase the total weight on foundations.

Electors Approve Tunnel Between Detroit and Windsor

The proposed international vehicular tunnel between Detroit, Michigan and Windsor, Ontario, sponsored by the Detroit-Ontario Subways, Inc., was approved by the electors of the city of Detroit by a majority of approximately two to one in the recent election.

The necessary amendment to the city charter is in the form of a day-to-day agreement giving the tunnel company the right to construct its tube under city properties. The tunnel company is to give the city a voice in the determination of tolls to be charged for passage through the tunnel. A purchase plan is provided for whereby the city may purchase the tunnel at any time after 20 years, and the tunnel is to be a gift to the city if it is not purchased before the expiration of 60 years.

The cross section of the subway will be circular and will have a deck supporting a 24 ft. roadway, with a ceiling clearance of 13 ft. 6 in. The total length between portals will be approximately 5,300 ft., with ventilating shafts 3,900 ft. apart.

Parsons, Klapp, Brickerhoff & Douglas, New York City, are the engineers in charge of design of the tunnel.

Model Registration Law Adopted by Council of State Licensing Boards

One of the outstanding matters handled at the recent convention of the National Council of State Boards of Engineering Examiners, held in Asheville, N. C., last week, was the unanimous adoption of the resolution endorsing the form of an act of legislation for registration of professional engineers recommended by the American Society of Civil Engineers and revised July 11, 1927, at the request of the National Council of State Boards of Engineering Examiners Committee.

The following officers were elected: President, George E. Taylor, Charleston, W. Va.; vice-president, James R. Rhyne, Corning, Ark., and secretary-treasurer, T. Keith Legaré, of Columbia, S. C. (elected for fifth time). The 1928 convention will be held at Little Rock, Ark.

Following are the states that have passed registration laws: Arizona, Arkansas, California, Colorado, Florida, Idaho, Indiana, Illinois (structural engineers and architects), Iowa, Michigan, Minnesota, Montana, New Mexico, New Jersey, New York, North Carolina, North Dakota, Tennessee, Virginia, West Virginia, Wisconsin, Wyoming and Hawaii.

Port Authority Fixes Location of Kill van Kull Bridge

The exact location of the new Kill van Kull bridge has been announced by the Port of New York Authority, information having been withheld hitherto pending extensive inquiry into the real estate and engineering phases of the work. Bonds for the project which is expected to cost less than $16,000,000 when opened to initial traffic, will be sold as speedily as possible after the War Department gives the necessary permission. This may mean the ground will be broken some time in the Spring.

The floor of the bridge will rise to a maximum clear height at the center of the span of 150 ft. above mean high water, under extreme conditions. At other points the clearances above mean high water under the same conditions will range from 135 ft. at any one point within a channel 1,000 ft. wide and 143½ ft. at any point within the present 400-ft. channel. The five East River bridges have a clear height of 135 ft. for a 400-ft. channel. The Camden-Philadelphia bridge has a clearance of 135 ft. for a channel 800 ft. wide.

The center line of the bridge will pass generally through the middle of the block between Avenue "A" and the Hudson Boulevard in Bayonne and through the block between Morningstar Road and Newark Avenue in Port Richmond, crossing the channel of the Kill van Kull at a considerable skew and in a general north and south direction.

Personal Notes

MORRIS KAMPF, consulting engineer New York, has taken over the office of the late George Benjamin of the same city. Mr. Kampf is a graduate civil engineer from Brooklyn Polytechnic Institute. He began his practice of engineering with Herbert C. Keith, consulting bridge engineer for the New York, New Haven & Hartford R.R. on bridge design work in New England. Following this, he was with Westinghouse, Church, Kerr & Co. as designing engineer and then with James Stewart & Co. in both design work and as a construction engineer. From 1924 to date he has been general manager and assistant to the president of E. D. Hyde, Inc.

HARLAND BARTHOLOMEW, engineer of the City Plan Commission, St. Louis, Mo., has been engaged by the city of Los Angeles to make a survey of park facilities there.

C. M. BAKER, state sanitary engineer of Wisconsin, has resigned to become a representative of the American Pulp & Paper Association, to assist in the study of stream pollution and industrial waste disposal problems of the paper manufacturing industry.

L. F. WARRICK, assistant sanitary engineer of the Wisconsin State Board of Health, Madison, Wis., has been appointed state sanitary engineer, succeeding C. M. BAKER, resigned.

ROY B. LEIGHTON, formerly a member of the firm of Grant, Fulton & Letton, consulting engineers, Oklahoma City, Okla., has entered the employ of the Arkansas State Highway Commission as a resident engineer in the bridge department.

J. M. BELKNAP, formerly office engineer for the Seaboard All-Florida Ry., is now field engineer for the Cincinnati Union Terminal Co. in charge of surveys for the new union passenger terminal at Cincinnati, Ohio.

E. C. MCADAMS, formerly an inspector in the Pennsylvania State Highway Department, has become an assistant engineer in the Mobile County highway department and is located at Mobile, Ala.

O. C. ROLLMAN, division engineer for the Wisconsin State Highway Department for ten years, has been appointed construction engineer, with office at Madison, Wis., to succeed F. M. BALSLEY, who has resigned to take a position with a road machinery company. D. F. CULBERTSON, assistant division engineer, has been appointed division engineer at Green Bay, Wis., to succeed Mr. Rollman.

N. M. ISABELLA, maintenance engineer of the Wisconsin State Highway Department, has been appointed division engineer at Wisconsin Rapids. He is succeeded by J. R. MCLEAN, who in turn is succeeded by H. F. HOLMES as division engineer at Superior, Wis.

Engineering Societies

Calendar

Annual Meetings

INTERNATIONAL ASSOCIATION OF STREET SANITATION OFFICIALS, Chicago, Ill.; Annual Conference, Detroit, Mich., Jan. 9-10, 1928.

AMERICAN ROAD BUILDERS ASSOCIATION, Washington, D. C.; Annual Convention, Cleveland, Ohio, Jan. 9-14, 1928.

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York City; Annual Meeting, New York City, Jan. 18-20, 1928.

ASSOCIATED GENERAL CONTRACTORS, Washington, D. C.; Annual Convention, West Baden, Ind., Jan. 23-27, 1928.

NATIONAL ASSOCIATION OF BUILDERS' EXCHANGES, Washington, D. C.; Annual meeting, Miami, Fla., Feb. 6-9, 1928.

THE GREATER NEW YORK AND NORTHERN NEW JERSEY SECTION of the Society for the Promotion of Engineering Education will hold its annual meeting at New York University, University Heights, on the afternoon and evening of Dec. 3. Inspection will be made of the new Nichols chemistry building and the newly opened Daniel Guggenheim School of Aeronautics.

THE ENGINEERS' CLUB OF ST. LOUIS has appointed a committee to co-operate with a committee of the St. Louis chapter of the American Institute of Architects in making a study of the effects of the recent tornado, with a view to discovering any lessons as to building design or construction which may be learned from these effects.

THE SOUTH CAROLINA WATER WORKS ASSOCIATION was organized at a meeting in Columbia Nov. 16 of the water-works men of the state; it is an independent state organization. A constitution and by-law were adopted and it was decided to hold annual meetings, the one in 1928 to be held at Camden. R. B. Sims of Spartanburg was elected president. H. W. Shumpert of Newberry vice-president, and A. E. Legare of Columbia secretary-treasurer.

THE BALTIMORE SECTION of the American Society of Civil Engineers at its Nov. 17 meeting had as guests the Johns Hopkins University Student Chapter. An illustrated lecture paper on the O'Shaughnessy dam and reservoir was presented by Prof. John H. Gregory of Johns Hopkins University.

THE IOWA SECTION OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS, held its annual meeting at Des Moines, Nov. 17, and elected officers as follows: President, A. H. Fuller, Iowa State College; vice-president, S. M. Woodward, University of Iowa; secretary, R. B. Kittredge, University of Iowa. Two papers on flood control were read by S. M. Woodward and O. W. Crowley.

Obituary

CHARLES H. NICHOLS, structural steel engineer, died recently at Bogota, N. J., aged 63 years. He was a native of Vermont and a graduate of Norwich University at Northfield, Vt. He designed the steelwork for many buildings in New York City, including one at Columbia University, and for buildings in Newark, N. J.

JOHN FAIR, civil engineer, died at his home in Brantford, Ont., on Oct. 31. He served for a great many years on the Brantford waterworks commission.

GEORGE CONLEY, drainage engineer of La Grange, Ind., died suddenly at Grady, Ark., on Oct. 24. Mr. Conley, who was 50 years of age, had been working in Jefferson County and other sections of Arkansas for the past two years.

T. HOWARD BARNES, consulting engineer, New York City, engaged for many years in engineering work in South and Central America, died Nov. 15 in Lima, Peru, aged 66 years. Mr. Barnes was born in Waltham, Mass., studied for a year, 1881, at Massachusetts Institute of Technology, then spent several years in the city engineer's office at Newton, Mass., in Texas, as city engineer of Medford, Mass., and in private practice in Boston on sewerage and other municipal problems. Since 1904 he had practiced in South and Central America on sanitation, hospital, port improvement and other public works projects for Latin-American municipalities and governments, and for many large corporations with interests in tropical countries, including the United Fruit Co. Mr. Barnes was a member of the American Society of Civil Engineers, the Boston Society of Engineers, the American Water Works Association, the New England Water Works Association, and the American Public Health Association.

JOHN R. GORDON, president of the Pioneer Construction & Engineering Co., Denver, Colo., died Nov. 19, aged 75 years. Mr. Gordon started in the engineering business many years ago with a surveying party along the Union Pacific R.R. in Nebraska.

ALSTON G. CULVER, New York City, who was an assistant engineer of the Board of Estimate for many years, died Nov. 24. Mr. Culver served in city work for fifty years; from 1884 to 1889 he was city water surveyor, and he had been connected with the finance department.

JOHN M. MARIS, Philadelphia, Pa., retired civil engineer, formerly vice-president of the United States Car Co., died Nov. 18 at his home in Philadelphia. Mr. Maris graduated in 1879 from the old Philadelphia Polytechnic Institute, followed engineering work with the Pennsylvania R.R. for some years, then with his father was a pioneer in building what were probably the first steel railway carriages in this country.

Construction Equipment and Materials

A Section Devoted to What the Manufacturer Is Doing for the Engineer and Contractor

Bucyrus-Erie Company Completes Organization Plans

The first meeting of the Bucyrus-Erie Co., the consolidation plan of which was presented to the stockholders last July, and subsequently approved by them, was held in New York, November 15. The following officers were elected by the board of directors: W. W. Coleman, president; E. K. Swigart, senior vice-president; F. B. McBrier, A. C. Vicary, D. P. Eells and W. M. Bager, vice-presidents; G. A. Morison, vice-president and treasurer, and J. G. Miller, secretary. W. W. Coleman will be chairman of the board of directors.

The two companies will continue to operate independently until January 1, 1928, after which time the assets of both companies will be taken over by the Bucyrus-Erie Co., and the merger will become effective. The offices of the company will be at South Milwaukee, Wis. and Erie, Pa., with manufacturing plants at South Milwaukee, Erie and Evansville, Ind. There will be one consolidated domestic sales organization under A. C. Vicary, now vice-president of the Erie Steam Shovel Co. D. P. Eells, now in charge of the foreign business of the Bucyrus Co., will be in charge of all foreign sales.

Plenty of Rooms for Road Show Guests

The hotel committee, American Road Builders' Association, reports that much progress has been made for handling the convention attendance for the Road Show in Cleveland January 9-14, and that it is now possible to state that visitors can be accomodated without undue taxing of the city's facilities.

The association's housing bureau is now and will be functioning up to the middle of show week. Visitors, instead of wandering from one hotel to another in search of accommodations, can be assigned to a room immediately through this housing bureau. Early reservations, it is stated, would help the bureau appreciably in handling its work. The housing bureau can be addressed at Room 394, Chamber of Commerce Building, Cleveland, Ohio.

Welding School at Purdue

The third annual conference on welding will be held at Purdue University, Lafayette, Ind., December 13-14-15, under the joint direction of the Engineering Extension Department and the Department of Practical Mechanics. The School of Chemical Engineering and the manufacturers of welding equipment will co-operate. The conference will deal with the use of electric, thermit and oxy-acetylene welding in its various fields. The conference in 1926 had an attendance of 228.

Business Notes

RACINE RADIATOR CO. has changed its name to the Perfex Corp. The change in name is due to change in location, and the word Perfex has been adopted because it is the registered trade mark. Large increases in sales of heavy duty type industrial radiators, during the past four years, led to the plant being moved from Racine to Milwaukee where better shipping facilities are available. The company is now in production in its new Milwaukee plant.

LITTLEFORD BROS., Cincinnati, Ohio, recently shipped what it believes to be the largest single order ever placed for tar and asphalt heaters. The order was received from the state highway department of Texas and called for 50 of the company's "Trail-O-Heaters," each having a capacity of 300 gallons, and equipped with a hand spraying attachment. The heaters will be used for the maintenance of roads throughout Texas.

AMERICAN VIBROLITHIC CORP., Des Moines, Iowa, announces the appointment of M. Russell Thayer as consulting engineer, with heaquarters in Des Moines. Mr. Thayer who has had varied experience on railroad work, with the Illinois highway department, the Universal Portland Cement Co., and the Portland Cement Association, joined the American Vibrolithic Corp. in 1921 as consulting engineer, operating in the Illinois territory. In his new capacity, Mr. Thayer will operate in all territories under the direction of the corporation.

HUNTER MACHINERY CO., Milwaukee, Wis., reports that its success in western Michigan following the establishment of a plant and offices at Grand Rapids, has been the cause of its taking over the eastern Michigan and the Detroit territory for many of the manufacturers which it represents. The capital of the Hunter Machinery Co. of Michigan, which is a separate corporation from the Hunter Machinery Co. of Wisconsin, has been increased by $110,000. A site has been purchased in Detroit, and a building will be erected which it is claimed will be one of the best equipment distributor's layouts in the central west. Morton R. Hunter is president; B. E. Uebele, formerly manager of the Grand Rapids office, has been made vice-president in charge of sales with headquarters at Detroit; and T. G. Abrams is treasurer. The manufacturers represented exclusively in the state of Michigan are: Chain Belt Co.; Blaw Knox Co.; Clyde Iron Works; Durex Co.; A. W. French & Co.; Northwest Engineering Co.; Sauerman Bros. Co.; Sullivan Machinery Co.; Aeroil Co.; Cleveland Wheelbarrow Co.; Pulsometer Steam Pump Co.; C. A. Londelius & Co.; Reynolds Portable Furnace Co.; Rowe Mfg. Co.

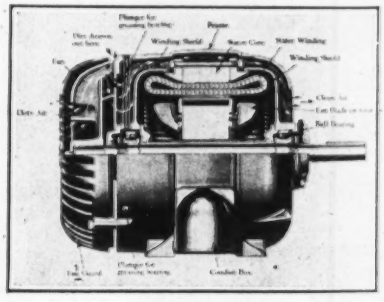
ARTHUR G. HENRICKS, vice-president, Harnischfeger Sales Corp., died, November 9, in Milwaukee. Mr. Henricks rose to the position of vice-president through the mechanical and electrical departments, and latterly in the sales department, first as sales engineer, then as general sales manager.

PETER HERB, for nineteen years connected with the New York office of the Blaw-Knox Co., as superintendent of erection, died suddenly at his home in Kingston, N. Y., November 8. Mr. Herb was fifty-five years old.

New Developments

Self-Ventilating Motors Use An Air Cleaning Device

A new product in the inclosed electric motor field is a development of the Fairbanks, Morse & Co., Chicago, in the form of a self-ventilated motor in which



the windings are entirely protected from air currents, and in which has been incorporated an air cleaning device.

Important advantages of this motor are claimed to be: (1) It is completely self-ventilated, cleaning its own cooling air by means of a built-in automatic air cleaner; (2) it is impervious to dust and dirt; (3) it is built in the same frame diameter as standard motors of corresponding horsepower; (4) no air piping of any kind is required; (5) it will operate in the dustiest location without requiring any blowing out; and (6) it reduces fire hazard as the windings are totally inclosed.

A standard stator core and windings

and a standard rotor are mounted in a supporting shell with an annular air passage in the outer surface of the stator core and the shell. The cooling air is drawn through an inlet opening at the free end of the motor by means of a special type fan which also functions as an air cleaner. The clean air is blown across the winding shield at the free end of the motor, through the annular air space, then across the outer end of the stator core laminations, thence across the winding shield at the pulley end and out through openings in the pulley-end bearing arm. Provision is made by means of a plunger device for lubricating the ball bearings of this motor without removing the guard, fan or bearing arms.

Liquid Chemical Application For Combating Rust

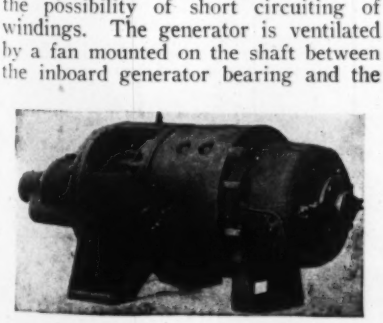
A liquid chemical, which is claimed to destroy rust by changing it from its active destructive state into an inert substance, is being manufactured by the Rusticide Co., 416 Frankfort Ave., Cleveland, Ohio, under the name of Rust-I-Cide.

It is said to be particularly useful in preparing the surface of construction machinery for winter painting. The coating formed by the Rust-I-Cide becomes part of the surface of the metal and the priming coat for the painting. It is said that paint placed over this coating will dry with a full lustre, and will retain its full wearing qualities. The Rust-I-Cide takes away the wearing power from the rust underneath which is claimed to be twice as great as the outside wearing power on a paint coat.

A 3-kw. Turbine Generator Unit for Construction Work

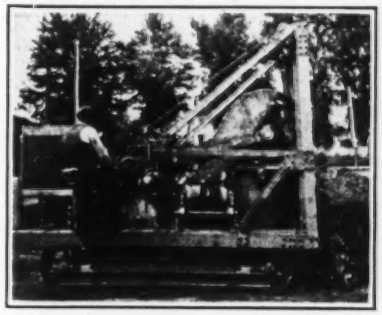
A direct connected turbine-generator unit, having a rating of 3-kw. at 125 volts direct current, and operating under ordinary steam conditions, has been developed by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., for application on outdoor construction work, oil well rigs, steam shovels, and isolated pumping plants. Simplicity of design and substantial construction are features which have been sought in the development of the unit.

The Westinghouse re-entry-type single impulse wheel turbine is used, and is overhung on the end of the generator shaft. The turbine and generator ends are completely isolated to insure against the possibility of short circuiting of windings. The generator is ventilated by a fan mounted on the shaft between the inboard generator bearing and the turbine casing. All parts are accessible for inspection by removing the turbine and the generator end covers. It is said that no expert attendance is required for the operation and maintenance since there are no delicate adjustments to make in the machine. In case of accidental overspeeding, the overhanging flange of the turbine rotor expands, filling the clearance space in the cylinder, and establishing a rubbing contact which sets up a braking action sufficient to restrain the speed of the unit within safe limits.



Rugged Construction and Modern Improvements in New Ditcher

A new model 150 service ditcher has been added to the present line of chain-and-bucket trench excavators manufactured by the Buckeye Traction Ditcher Co., Findlay, Ohio. Some of the operating dimensions of this new ditcher are: Cutting width, 16, 18, 20, 22, 24, and 26 in.; cutting depth, 0 to 4 ft., 6 ft. and 8 ft.; overall dimensions are: Width, 6½ ft.; height with boom raised for travel, 10 ft.; length (set for 8-ft. cut and boom raised), 21 ft. 8 in.; length, with boom at maximum digging depth, 18 ft. The approximate weight of the machine is 18,000 lb. and, it is claimed, that its construction is 98 per cent steel excluding the power unit. The main frame consists of four longitudinal sills of 7-in., 12.25-lb. channel. The ditcher is mounted on two full-length crawlers, giving a bearing pressure



of 7 lb. per sq.in. The excavator boom is of box girder construction, with buckets of one-piece electric cast steel. Two bucket line speeds provide operating efficiency in all soils. Change of speed is effected by merely shifting a lever at the operator's platform. The boom when raised is carried over the main machine, giving proper road balance and eliminating top heaviness.

An improvement has been made permitting this model to dig while traveling backward. This provides means for digging straight down beside a wall or a building, since nothing projects or is carried back of the bucket line. A safety sprocket, provided at the end of the excavator shaft, avoids severe breakage in case an overload obstruction is encountered. This sprocket releases upon meeting such an obstruction, but automatically returns immediately to its normal working position.

Standard cutting speeds are 12.8 in., 18.1 in., 35.7 in., and 66.4 in. per min., although other gears can be furnished to provide four higher or lower speeds. The discharge belt has two working speeds, it being possible to change instantly from one to the other. The power unit is a heavy duty, 5-in. bore by 6¼-in. stroke gasoline engine developing 52 hp. at 900 r.p.m.

Manufacturers and Trade Associations

Calendar

Annual Meetings

NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING. Sixth Annual Show. New York City, Dec. 5-10.

POWER TRANSMISSION ASSOCIATION, Philadelphia; Annual meeting, New York City, Dec. 7.

EASTERN PAVING BRICK MFGRS. ASSN., Philadelphia; Annual meeting, Pittsburgh, Dec. 13.

NATIONAL SAND AND GRAVEL ASSOCIATION, Washington, D. C.; Annual Convention, Detroit, Jan. 4-6, 1928.

ASSOCIATED EQUIPMENT DISTRIBUTORS, Milwaukee; Annual meeting, Cleveland, Jan. 6-7, 1928.

AMERICAN ROAD BUILDERS ASSOCIATION, Washington, D. C.; Annual Convention, Cleveland, Ohio, Jan. 9-14, 1928.

NATIONAL CRUSHED STONE ASSOCIATION, Washington, D. C.; Annual Convention, West Baden, Ind., Jan. 16-19, 1928.

New Publications

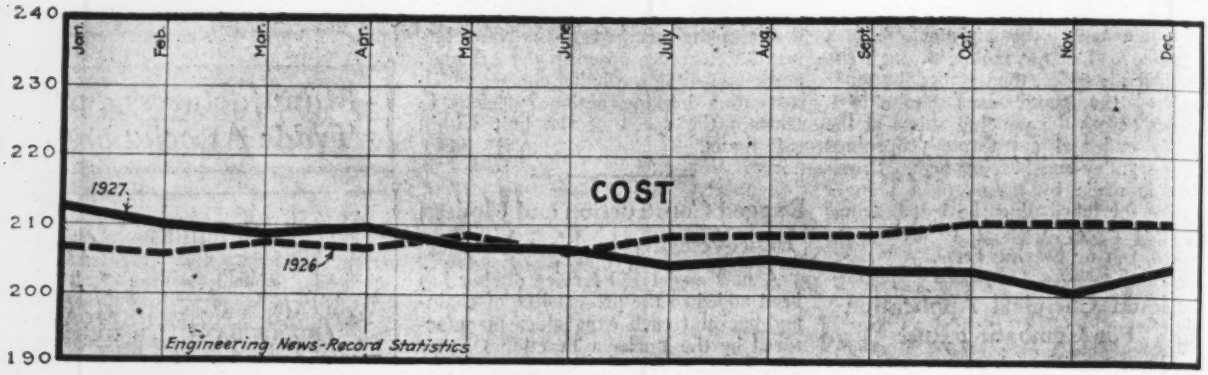
Power Shovel Capacity—HARNISCHFEGER CORP., Milwaukee, Wis., has published a small booklet entitled "What Is Capacity?" in which it describes the various mechanical and construction features of its shovels as contributing to maximum and sustained output. The text of the booklet is that shovel capacity is not dipper capacity unless the shovel machinery can turn out big yardage over a long period of time without excessive wear, and at a low cost.

Cranes and Trolleys—H. D. CONKEY & Co., Mendota, Ill., has issued a 43 page catalog giving complete specifications, clearances and other information on its crane and trolley equipment for general manufacturing plants, structural shops, etc. In the back of the book are two pages listing some of the companies using Conkey crane installations.

Pulverizers—A 22-page pamphlet has recently been issued by Bethlehem Steel Co., setting forth the advantages in the use of its pulverizer for the fine grinding of coal, culm, gypsum, dolomite, magnesite, silica sand, marble, fire clay, ore and other hard products. Aside from the usual photographs of the machine and section details, graphical charts are given on performance, power consumption and air conditions.

Engineering News-Record Statistics of the Construction Industry

December 1, 1927 — *in the United States* — Vol.99, No.22



Engineering News-Record CONSTRUCTION COST Index Number (1913 = 100)

MONTHLY
January, 1926, to Date

December, 1927	203.90
November, 1927	201.98
December, 1926	210.80
Peak, June, 1920	273.80
1913	100.00

1926

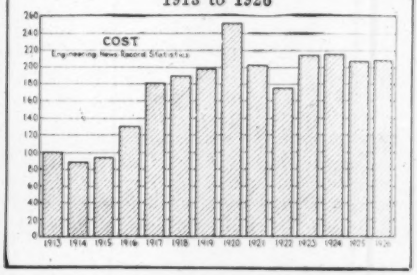
Jan.	207.15	May	207.30	Sept.	208.30
Feb.	206.55	June	204.80	Oct.	209.80
Mar.	207.65	July	207.80	Nov.	210.80
April.	207.05	Aug.	208.30	Dec.	210.80

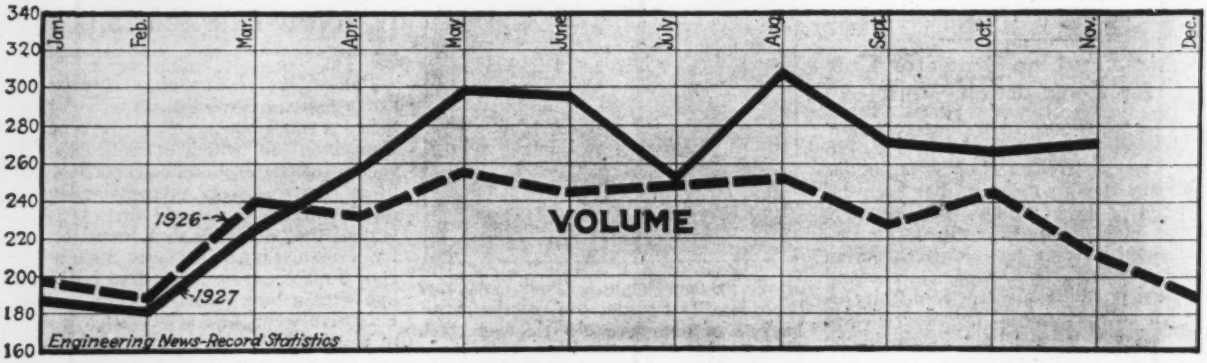
1927

Jan.	211.50	May	206.80	Sept.	203.60
Feb.	210.15	June	205.55	Oct.	204.40
Mar.	208.80	July	203.68	Nov.	201.98
April.	209.00	Aug.	205.50	Dec.	203.90

Engineering News-Record's Construction Cost Index Number is 0.9 per cent above November, 1927. The increase is due to slightly higher prices for steel, lumber, and common labor. The average rate for common laborers is 55c. per hour. Thus, general construction cost is 3.2 per cent below December, 1926, and 25 per cent under the peak. It is also 103 per cent above 1913.

YEARLY
1913 to 1926





Engineering News Record CONSTRUCTION VOLUME Index Number (1913 = 100)

MONTHLY
January, 1926, to November, 1927

November, 1927	272
October, 1927	269
November, 1926	211
1913	100

1926

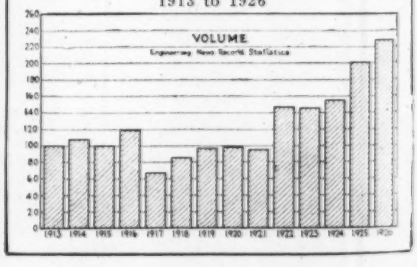
Jan.	198	May	254	Sept.	227
Feb.	187	June	246	Oct.	244
Mar.	240	July	248	Nov.	211
April.	233	Aug.	252	Dec.	188

1927

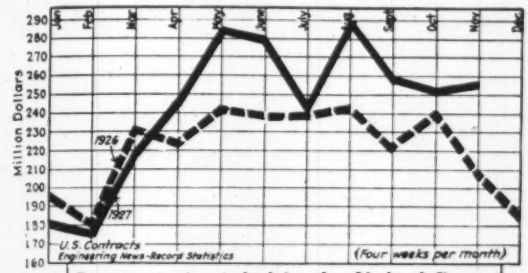
Jan.	187	May	299	Sept.	273
Feb.	182	June	297	Oct.	269
Mar.	226	July	252	Nov.	272
April.	257	Aug.	306		

Engineering News-Record's Construction Volume Index Number is 272 for the month of November and 228 for the whole of 1926, as against 100 for 1913. This means that the actual volume of contract letting in 1926 (not the mere money-value of the contracts let that year) is 128 per cent above the volume for 1913. The monthly volume number, 272 for November, 1927, indicates the rate at which contracts are being let as compared with 1913 awards.

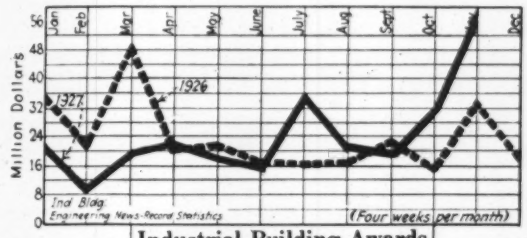
YEARLY
1913 to 1926



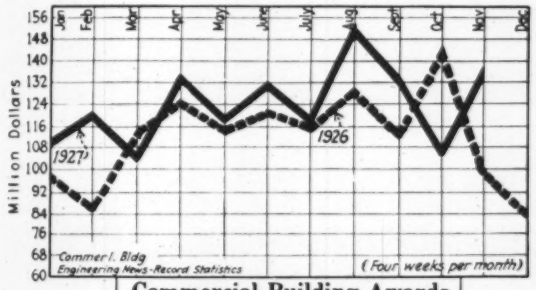
Monthly Statistics of the Construction Industry



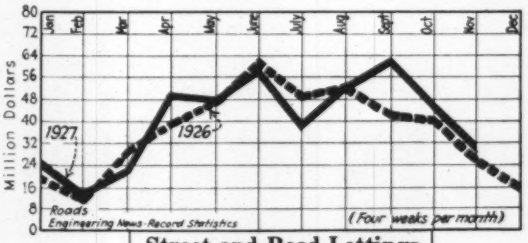
Contracts Awarded in the United States
Reported by E. N.-R.



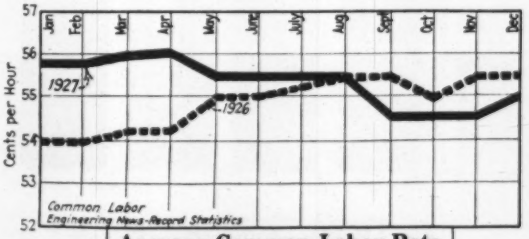
Industrial Building Awards
$40,000 and Over



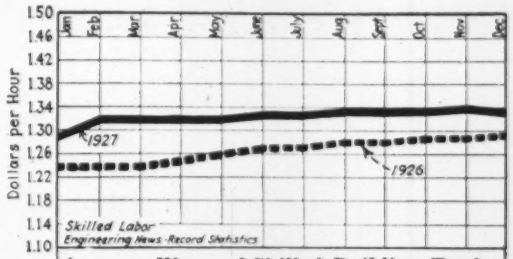
Commercial Building Awards
$150,000 and Over



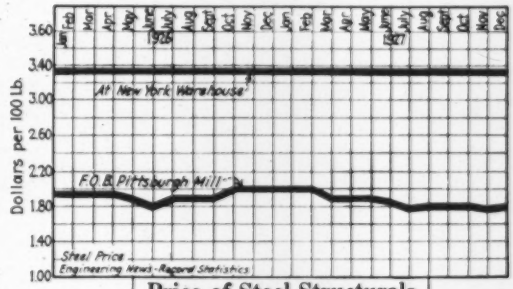
Street and Road Lettings
$25,000 and Over



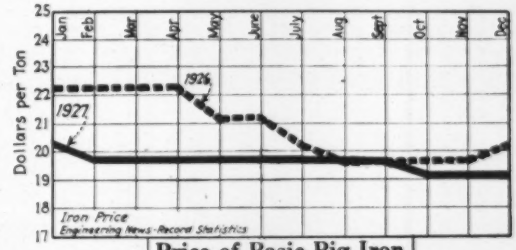
Average Common Labor Rate
Pick and Shovel Men



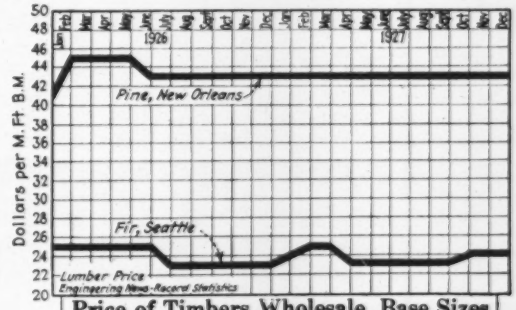
Average Wage of Skilled Building Trades
Bricklayers, Carpenters and Steel Erectors



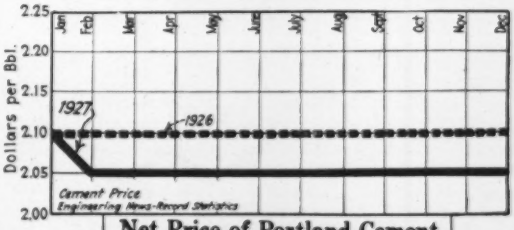
Price of Steel Structurals
Shapes 3-in; Plates ¼-in.



Price of Basic Pig Iron
F.o.b. Pittsburgh

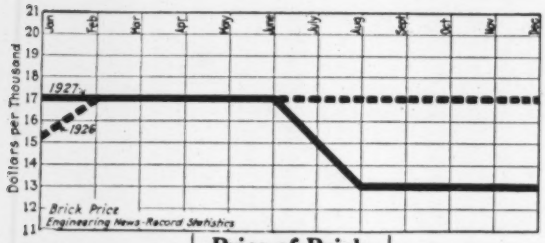


Price of Timbers, Wholesale, Base Sizes
Car Lots to Contractors

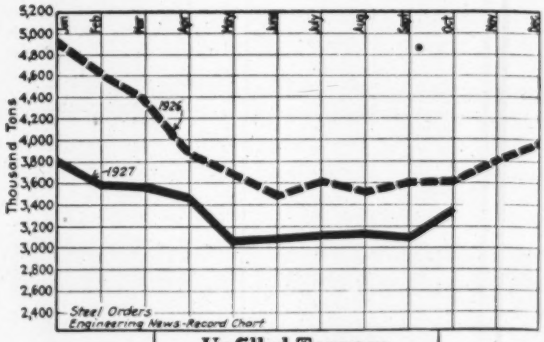


Net Price of Portland Cement
Car Lots F.o.b. Chicago

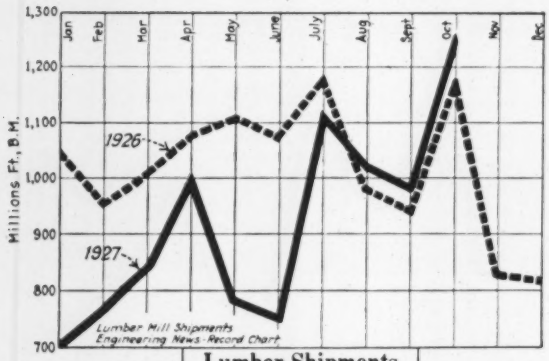
Monthly Statistics of the Construction Industry



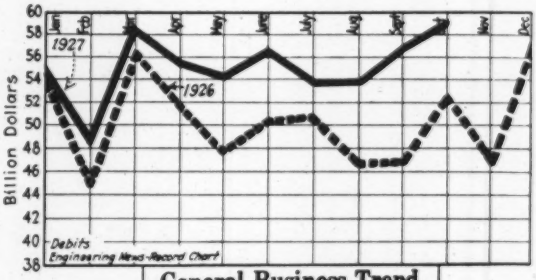
Price of Brick
At Dock, New York



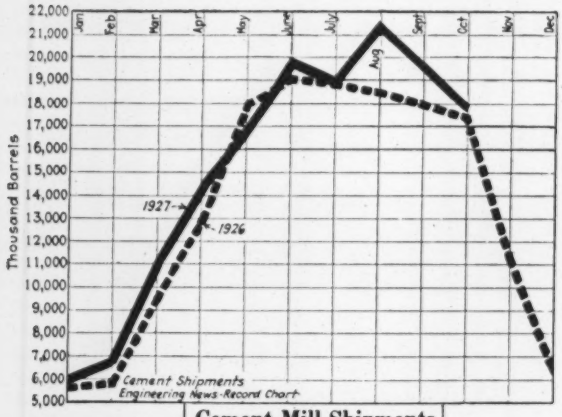
Unfilled Tonnage
On Books of U. S. Steel Corp.



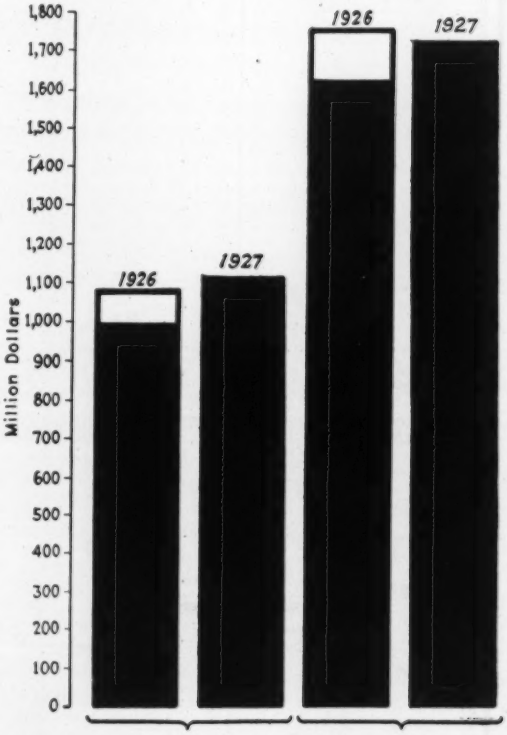
Lumber Shipments
Nat. Lumber Mfrs. Assn.



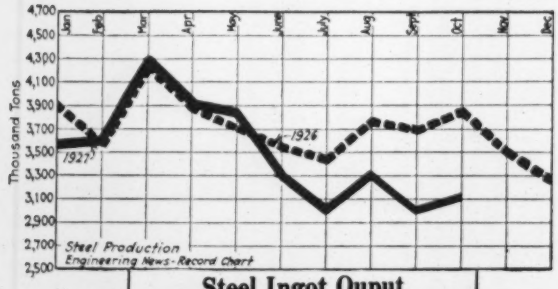
General Business Trend
Bank Debits—Federal Reserve



Cement Mill Shipments
Bureau of Mines



Public—Contracts—Private
Jan. 1 to date ——
Reported by E. N.-R.



Steel Ingot Ouput
Gross Tons; Am. Iron and Steel Inst.

Construction Industry Continues High Activity Through November

1926 Totals Surpassed in Eleven Months of 1927

THE total value of contracts awarded in November was $257,322,000, an increase of 2.1 per cent over October, 1927, and 20 per cent over November, 1926, according to *Engineering News-Record* statistics, which included reports for four weeks for each of the months here compared.

The year 1927 to date is 9.7 per cent higher than the same period last year. Awards for private work this year are 5.9 per cent ahead of 1926 and public contracts 15.8 per cent more than last year. Based on *E. N.-R.* Volume Index, which makes allowance for the decrease in construction costs during 1927, contracts for all classes of work are 11 per cent higher than the first eleven months last year.

Commercial building in 1927 increased 7 per cent over the first eleven months of last year. About 84 per cent of commercial building is private and this class increased 6 per cent, while public building increased 13.3 per cent. Although industrial building contracts are 100 per cent larger than last month, the year to date is .65 per cent less than the same period last year. The industrial contracts for November are considerably larger than any month on record and one large project, a $37,500,000 factory being constructed at Happy Valley, Tenn., for the American Glantzstoff Co. accounts for this large volume.

Contracts in 1927 for all buildings increased $92,951,000 or 5.6 per cent over the same months last year and construction other than building increased $158,727,000 or 16.2 per cent. November building awards were larger than any month on record.

Cumulative totals for industrial work during the past three years is given in the following table. The November volume brought the total to $289,000,000—only $1,900,000 less than the same date last year.

TABLE I.—INDUSTRIAL CONTRACTS CUMULATED
(Millions of Dollars)

	1925	1926	1927
January	19.7	35.3	21.6
February	27.1	57.5	31.1
March	40.2	107.4	55.6
April	57.9	134.5	79.0
May	70.6	156.8	97.9
June	88.7	174.6	117.2
July	100.7	196.3	152.4
August	131.5	213.6	173.0
September	165.5	243.1	197.6
October	200.1	258.5	228.3
November	216.0	291.3	289.4
December	227.6	311.7	.....

The sections of the country in which awards during 1927 have been in larger volume than the first eleven months of 1926 are Middle Atlantic, Middle West, West of Mississippi, and Far West. All classes of construction except waterworks and industrial building exceed the 1926 totals.

Compared with last month, November shows increases in waterworks, industrial and commercial building, and all private construction. November, 1927 is likewise higher than November, 1926 in awards for bridges, streets and roads, all buildings, federal government, and public unclassified projects.

At the beginning of the year conditions pointed to continued high activity in the construction industry but 1927 was not expected to surpass the very high totals of last year. This year has, however, reached in eleven months, the volume recorded in the twelve months of last year and exceeds 1926 by .84 per cent. Classes of construction contributing to this larger volume which show totals to date larger than at the end of 1926 are: sewers, bridges, excavations, streets and roads, public building and unclassified work. All private work is 2.3 per cent under and public work 6 per cent over the 1926 totals.

TABLE II— VALUE OF CONTRACTS BY SECTIONS IN THE UNITED STATES AND TOTAL FOR CANADA—NOVEMBER, 1927
Thousands of dollars (-000 omitted)

	New England	Middle Atlantic	South	Middle West	West of Mississippi	Far West	United States	Jan. 1 to Dec. 1, U. S.	Canada
Waterworks	$32	$517	$15	$914	$1,214	$608	$3,300	$50,634	$89
Sewers	503	1,284	624	4,421	791	648	8,271	110,481	78
Bridges	25	2,699	2,059	1,422	1,321	703	8,229	127,880	.....
Excavations, drainage	.....	68	474	76	138	96	852	40,201	323
Streets and roads	425	3,185	1,674	4,305	15,246	5,043	29,878	486,456	442
Industrial buildings	2,213	5,865	42,917	6,545	4,438	1,041	61,019	289,355	522
Commercial buildings	11,374	62,756	4,484	38,112	6,942	10,668	134,336	1,456,707	4,867
Federal government	23	814	282	497	23	1,995	3,634	47,034	.....
Unclassified	440	995	263	5,355	700	70	7,803	267,174	5,034
November, 1927	$15,035	$76,183	$52,792	$61,627	$30,813	$20,872	$257,322	.....	$11,355
October, 1927	9,360	81,485	21,994	53,262	46,591	39,296	251,988	.....	29,795
November, 1926	24,031	53,308	26,659	56,660	24,303	21,860	206,821	.....	40,313
Jan. 1 to Dec. 1, 1927	212,624	854,869	260,416	709,228	493,467	345,318	2,875,922	$2,875,922	129,687
Jan. 1 to Dec. 1, 1926	227,349	791,276	269,319	666,719	381,543	285,977	2,622,183	2,622,183	140,700

Labor Rates and Conditions Throughout the Country

No Strikes of Importance Now Active—Few Wage Changes

AN ABSENCE of important strikes or wage controversies and few possibilities of the development of serious labor troubles in the near future, characterize the closing month of 1927, in the principal cities throughout the United States and Canada, according to reports received by *Engineering News-Record*.

Settlement, during the month, of the Toronto carpenters strike, eliminates the last disturbing factor of importance, from the construction field. Carpenters in Toronto are to receive $1 per hr., beginning Jan. 1, 1928; the closed-shop clause in their original demands, however, was not met by the employers.

With the abolition of the Board of Jurisdictional Awards came a resumption of the ill-will that has smoldered for some time between bricklayers and plasterers, marble setters and glaziers, over placing of certain materials. There is reported unrest among hoisting engineers also, at various points. The proffered assistance of organized bricklayers, plasterers, and masons in the attempt to unionize New York subway workers, is not regarded as containing serious possibilities.

The volume of heavy engineering construction this year, is greater than in 1926. Despite the foregoing, building trades mechanics hesitate to push wage demands or to place undue stress on the five-day week plan. This attitude on the part of construction labor, is undoubtedly due to an appreciation of the weak spot in an otherwise expanding industry. This weak spot is confined practically to buildings of a speculative type, namely, stores, offices, apartments, and other residential structures.

Starting trades in building construction, also highway and railroad maintenance work are entering the three-months period of seasonally low activity, with consequent surplus of laborers in many cities. Northwestern lumber mills report reduced cutting schedules. With steel mill operations at approximately 60 per cent of capacity, for the nation as a whole, the recent up-turn in prices may have the effect of preventing wage reductions at some of the plants.

In industries not related to construction, the present trend is toward a slowing down in factory operations. According to the U. S. Employment Service, this recession affects mainly the following industries: Agriculture, fruit canning, railway repair shops, and train service departments. The textile and

Current Building Trades Wage Rates Per Hour

(Higher rates than a month ago indicated by +, decreases by—)

Cities	Bricklayers	Carpenters	Hoisting Engineers	Hod Carriers	Pile Drivers	Structural Iron Workers	Common Labor
Atlanta	$1.40	$0.70	$0.70	$0.50	.....	$0.75	$0.25@.30
Baltimore	1.62½	1.00@1.10	1.00@1.37½	1.00	$0.65	1.00@1.25	.40
Birmingham	1.00@1.50	1.05	1.00	.50@.75	.....	1.75	.25@.40
Boston	1.40	1.25	1.25	.79	1.15	1.25	.45@.74
Cincinnati	+1.50	1.37½	1.37½	.97½	1.37½	1.37½	.45@.60
Chicago	1.62½	1.10@1.50	1.00@1.50	.90@.96¼	1.50	1.50	.82½@.90
Cleveland	1.62½	1.37½	1.37½	.87½	1.10	1.50	.87½
Dallas	1.62½	1.12½	1.00	.40@.75	1.00	1.25	+ .40@.50
Denver	1.50@1.62½	1.25	1.25@1.37½	.87½@1.00	....	1.25	.31¼@.50
Detroit	1.56¼	1.00@1.25	1.00@1.10	.90	1.00@1.10	1.00@1.25	.50@.60
Kansas City, Mo	1.50	1.25	1.25	.90	1.25	1.25	.35@.75
Los Angeles	1.37½	1.00	1.00	.86½	1.18½	1.00	.50
Minneapolis	1.25	.87½@95	.87½	.75	....	1.00	.45@.60
Montreal	1.25	.75	.75	.40	.50	1.00	.30@.35
New Orleans	1.50	.90	1.25	.75	.80@1.00	1.25	.30@.40
New York	1.75	1.50	1.75	1.12½	1.00@1.12½	1.75	.90½
Philadelphia	1.62½	1.12½@1.25	1.02¼	.70@1.12½	1.00	1.37½@1.50	.45@.50
Pittsburgh	1.70	1.50	1.50	1.12½	....	1.50	.50@.80
St. Louis	1.75	1.50	1.50@1.65	1.15@1.25	1.25	1.50	—.45@.75
San Francisco	1.37½	1.12½	1.00@1.12½	.87½	1.12½	1.37½	.50@.60
Seattle	1.37½	1.12½	1.00@1.12½	1.00	1.00@1.12½	1.12½@1.25	.62½@.70

automotive industries record little change from recent levels of activity; cigar making and meat packing show gaining tendencies.

In the following table, wage rates are given on crafts other than those included in the table at the top of this page.

ST. LOUIS

Trade	Rate per Hr.
Boiler makers	$1.25
Boiler makers' helpers	1.00
Cement finishers	1.50
Concreters	.87½
Concreters, blockmen	.92½
Electricians	1.50
Electricians' helpers, 1st year	.40
Electricians' helpers, 2nd year	.50
Electricians' helpers, 3rd year	.60
Electricians' helpers, 4th year	.70
Elevator constructors	1.60
Elevator constructors' helpers	1.12

Trade	Rate Per Hour
Engineers, 1 and 2 drum hoists	1.50
Engineers, 3 drum hoists	1.65
Excavators	.75
Gas fitters	1.25
Glass cutters (Art)	.90
Glass lead glaziers (Art)	.85
Glass metal glaziers (Art)	.90
Glass blockers (plate and mirror)	.85
Glass buffers	.90
Glass emeryers	.90
Glass polishers	.90
Glass roughers	.90
Glass scratch markers	.90
Glass scratch polishers	.90
Glass smoothers	.90
Glass silverers	.90
Glaziers, putty	1.50
Hodcarriers, mortar	1.15
Hod carriers, plaster	1.25
Hod carriers, brick	1.15
Housemovers	1.00
Iron erectors, ornamental	1.50
Iron erectors' helpers	.67½
Iron erectors, structural, helpers	.67½
Laborers, building	.75
Lathers	1.50

Trade	Rate Per Hour
Marble cutters	.72½
Marble setters	1.37½
Marble setters' helpers	.80
Millhands	.85
Millwrights	1.50
Painters	1.43¾
Paper hangers	1.30
Pipe coverers	1.31¼
Pipe coverers, helpers	.60
Plasterers	1.75
Plumbers	1.50
Plumbers' laborers	.93¾
Roofers, gravel and composition	1.25
Roofers, laborers	.60
Roofers, slate and tile	1.50
Sheet metal workers	1.50
Sprinkler fitters	1.12½
Steam fitters	1.50
Steam fitters' helpers	.87½
Stone cutters	1.25
Stone cutters' helpers	.90
Stone masons	1.50
Stone masons' helpers	1.00
Tile setters	1.50
Tile setters' helpers	.80
Wreckers	.61¼

Monthly Prices of Construction Materials

Cast-Iron Pipe Decline Slight—Steel Rises

COST of construction materials together with that of labor, has remained below 1926 levels during the last half of the current year. With costs lower, more money has been spent for engineering construction this year, than last, as shown by contract totals on p. 899. As a result of increased demand, several of the basic materials continue to resist the usual seasonal price decline.

Price advances appear in the accompanying table, on manila rope, steel rivets, hollow tile, wood paving blocks, hydrated lime, and linseed oil.

In the last mentioned material, prices rose ¾c. at New York and 4c. per 7½ lb. gal. in Chicago, compared with November levels.

The flaxseed market continues quiet, with tendency toward neither an advance nor a decline.

The price increase of 5c. per 100 lb., during the last month, in the three principal hot-rolled steel products at mills, met with little resistance from principal consumers of this material. The minimum on bars, shapes, and plates is $1.80 per 100 lb., base, Pittsburgh, for large tonnages. A quotation of $1.85 applies on carlots, with less-than-carload quantities selling at $1.90 per 100 lb., Pittsburgh.

Demand is unseasonally heavy in reinforcing bars; shapes are gaining; there is considerable activity in buying of lap-weld steel pipe for oil and gas line construction. Increased purchasing of hot-rolled steel is probably due more to anticipation of further advance in price than to actual requirements.

The two outstanding contracts involving gas line pipe, awarded during the last month, were 344 mi. in Texas, New Mexico, and Colorado, for the Canada River Gas Co., together with the Colorado Interstate Gas Co., let to Ford, Bacon, & Davis, Inc., $16,000,000; 432 mi. in Louisiana, Arkansas, and Missouri, for the Moody & Seagraves Co., to be constructed by company forces, $20,000,000.

Slowness prevails in current purchasing of pig iron (except foundry), steel sheets, and iron and steel scrap. In contrast with the rise in prices of billet-steel bars at Pittsburgh, is the report of a 5c. per 100 lb. decline in rail-steel bars at St. Louis.

Quotations in the accompanying table are found to have declined from November levels, in the following materials: pig iron, iron and steel scrap, railway ties, cast-iron pipe, large-size sewer pipe, crushed stone, cement, brick, nails, steel sheets, and lumber, except pine timbers and 1-in. pine boards. Western lumber stocks remain at seasonal normal.

The declining tendency in cast-iron pipe prices is becoming less severe, from month to month. The November level was $2 per ton below that of the month preceding, while the current price of $27.50 per net ton, f.o.b. Birmingham, on 6-in., Class B, carload lots, is only 50c. per ton below the November quotation.

The maximum on common brick dropped $1 per M in New York, St. Louis, and San Francisco, during the last month. Hollow tile prices are stiffening at production centers.

E. N.-R. Prices of Construction Materials

Price advances since last month are indicated by **heavy type**; declines by *italics*

PIG IRON—Per Gross Ton, f.o.b.:

	Dec. 1	One Year Ago
CINCINNATI		
No. 2 Southern (silicon 2.25@2.75)	**$21.44**	$24.19
Northern Basic	20.89	20.89
No. 2 Southern Ohio (silicon 1.75@2.25)	21.19	21.39
NEW YORK, tidewater delivery		
Southern No. 2 (silicon 2.25@2.75)	**25.62**	26.37
BIRMINGHAM		
No. 2 Foundry (silicon 2.25@2.75)	*16.00*	20.00
PHILADELPHIA		
Eastern Pa., No. 2X (2.25@2.75 sil.)	**21.76**	23.76
Virginia No. 2 (silicon 2.25@2.75)	**27.17**	28.19
Basic	**21.26**	21.26
CHICAGO		
No. 2 Foundry Local (silicon 1.75@2.25)	*20.00*	21.00
No. 2 Foundry Southern (silicon 2.25@2.75)	**22.80**	24.55
PITTSBURGH, including freight charge ($1.76) from the Valley		
No. 2 Foundry Valley (silicon 1.75@2.25)	20.26	20.76
Basic	*19.26*	20.26
Bessemer	21.26	21.26

SCRAP—The prices following are f.o.b. per ton paid by dealers:

	New York	Chicago
No. 1 railroad wrought	*$10.50@$11.00*	*$9.75@$10.25*
Stove plate	*8.25@ 8.50*	*11.75@ 12.25*
No. 1 machinery cast	**12.50@ 14.00**	*13.75@ 14.25*
Machine shop turnings	*6.00@ 7.00*	*6.50@ 7.00*
Cast borings	*6.75@ 7.25*	*8.50@ 9.00*
Railroad malleable	*10.00@ 10.50*	*11.00@ 11.50*
Re-rolling rails	*10.00@ 10.50*	*12.50@ 13.00*
Re-laying rails	**23.00@ 24.00**	.....
Heavy melting steel	*6.25@* **10.75**	*10.25@ 10.75*
Iron and steel pipe	**8.75**	.....

Railway Supplies

STEEL RAILS—The following quotations are per gross ton f.o.b. for carload or larger lots. For less than carload lots 5c. per 100 lb. is charged extra:

	Pittsburgh Dec. 1	Pittsburgh One Year Ago	Birmingham	Chicago	St. Louis
Standard bessemer rails	$43.00	$43.00	$43.00	$43.00	.....
Standard openhearth rails	43.00	43.00	43.00	43.00	$49.50
Light rails, 8 to 10 lb.	.....	.....	34@36	1.80@1.90*	1.90*
Light rails, 12 to 14 lb.	36.00	.....	34@36	1.80@1.90*	1.80*
Light rails, 25 to 45 lb.	36.00	36.00	34@36	1.80@1.90*	1.78*
Re-rolled rails	30@34	28@30	34@36	34@36	.....

*Per 100 lb.

RAILWAY TIES—For fair-sized orders, the following prices per tie hold:

	6 In. x 8 In. by 8 Ft.	7 In. x 9 In. by 8½ Ft.
Chicago, white oak, plain	$1.45	$1.83
Chicago, empty cell creosoted	1.85	2.45
Chicago, zinc treated	1.65	2.15
San Francisco, green Douglas fir	.84	1.14
San Francisco, empty cell creosoted, Douglas fir	1.70	2.25
St. Louis, white oak, plain	1.25	1.50
St. Louis, zinc treated	1.65	1.90
St. Louis, red oak, plain	1.15	1.40
St. Louis, sap pine-cypress	*.95*	*1.20*
Birmingham, white oak	1.25	1.45

TRACK SUPPLIES—The following prices are base per 100 lb. f.o.b. Pittsburgh mill for carload lots, together with the warehouse prices at the places named:

	Pittsburgh Dec. 1	Pittsburgh One Year Ago	Chicago	St. Louis	San Francisco	Birmingham
Standard spikes, ⅝-in. and larger	$2.80	$2.80@2.90	$3.55	$3.65	$3.85	$3.00
Track bolts	3.80	3.90@ 4.25	4.55	4.60	5.35	3.90
Standard section angle bars, splice bars or fish plates	**2.80**	2.85@2.95	3.40	3.75	4.25	2.95
Tie plates	2.25	.....	....	....	....	....

Pipe

WROUGHT STEEL AND IRON PIPE—The following discounts from list are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13
LAP WELD					
1	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 to 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

WROUGHT-STEEL PIPE—From warehouses at the places named the following discounts from list, hold for welded steel pipe:

	Black New York	Black Chicago	Black St. Louis
1 to 3 in. butt welded	53%	54%	49%
2½ to 6 in. lap welded	48%	51%	46%

	Galvanized New York	Galvanized Chicago	Galvanized St. Louis
1 to 3 in. butt welded	39%	41%	36%
2½ to 6 in. lap welded	35%	38%	33%

Malleable fittings, Classes B and C, banded, from New York stock sell at list plus 4% less 5%. Cast iron, standard sizes, 36—5% off.

CAST-IRON PIPE—The following are prices per net ton for Class B and heavier, f. o. b., in carload or larger lots:

	Birmingham	Burlington, N. J.	New York Dec. 1	New York One Year Ago
4 in.	*$30.50*	*$39.00*	*$41.60*	$54.60
6 in. and over	*27.50*	*36.00*	*38.60*	50.60
	Pittsburgh	Chicago	St. Louis	San Francisco
4 in.	*$39.00*	*$38.70*	*$36.10*	$51.50
6 in. and over	*36.00*	*35.70*	*33.10*	48.50

Gas pipe and Class "A," $3.00 per ton extra.

CLAY DRAIN TILE—The following prices are per 1,000 lin.ft.:

Size, In.	New York Dec. 1	New York One Year Ago	St. Louis	Birmingham	San Francisco	Dallas
3	$45.00	$45.00	.....	$45.00	.....	$73.00
4	56.00	55.00	$35.00	56.00	$76.50	90.00
5	.....	.....	.....	80.00	97.75	118.00
6	80.00	90.00	65.00	100.00	127.50	150.00
8	150.00	160.00	150.00	165.00	212.50	210.00

SEWER PIPE—The following prices are in cents per foot for standard pipe in car load lots, f.o.b., except as otherwise stated:

Size, In.	New York Delivered	Pittsburgh	Birmingham	St. Louis	Chicago	San Francisco	Dallas
3	....	$0.072	$0.10	.....	$0.088	$0.12	.....
4	....	.072	.10	$0.0875	.088	.15	$0.15
5	.....	.099	.135	.....	.11	.18	.18
6	$0.22	.099	.21	.1225	.11	.21	.21
8	.36	.162	.315	.20	.18	.30	.38
10	.52	.2415	.45	.28	.2625	.42	**.55**
12	.66	.3105	.54	.36†	.3375	.56	.70
15	1.12†	.414	.75	.60†	.45	.92	1.01
18	1.62†	.575	.90	.84†	.825†	1.32	1.32
20	1.95†	.69	1.20	.....	1.05†	.....	.....
21	.....	.805	.....	1.12†	1.225†	....	.....
22	2.60†	.92	1.35	.....	1.40†	.....	1.83
24	2.92†	1.035	2.665	1.44†	1.575†	2.16	2.27
27	4.62†	2.08	2.952	2.45†	2.75†	3.00	3.34
30	5.12†	2.304	3.96	3.00†	3.75†	3.60	4.06
33	6.93†	4.05	4.51	3.55†	4.50†	....	4.99
36	7.91†	4.6125	5.06	3.95†	5.00†	.....	5.42

	3	5	8	12	24	36
Boston	$0.125	$0.175	$0.25	$0.47	$1.80†	*$5.00*†
Minneapolis	.....	.....	.25	.45	1.50	4.56
Denver	.135*	.18*	.27	.47	1.70	.....
Seattle	.14	.....	.35	.63	2.52	.....
Los Angeles	.1675	.186	.2825	.5085†	2.034†	.....
New Orleans	.11*	.165*	.275	.4675	1.7875	3.50
Cincinnati	.105	.1575	.245	.4725	1.575	4.715
Atlanta	.10*	.15*	.25	.425	1.625	.....
Montreal	....	.25	.45	.675	**2.275**	.....
Detroit	.081	.122	.189	.405	2.07†	4.715†
Baltimore	.111	.166	.259	.499	1.665	4.92
Kansas City, Mo.	.15*	.21*	29	.52	1.90†	3.80†
Philadelphia	*.10*	*.14*	*.235*	*.38*	*1.33*	*3.32*

*4-in., 6-in., 9-in., respectively. †Double Strength.

Road and Paving Materials

ROAD OILS—Following are prices per gallon in tank cars, 8,000 gal. minimum f.o.b. places named:

	Dec. 1	One Year Ago
New York, 45% asphalt (at terminal)	$0.0725@$0.075	$0.065 @$0.07
New York, 65% asphalt (at terminal)	.0675@ .0725	.0675@.0725
New York, binder (at terminal)	.07 @ .075	.07 @.075
New York, flux (at terminal)	.07 @ .075	.07 @.075
New York, liquid asphalt (at terminal)	.07 @ .075	.07 @.075
St. Louis, 40@50% asphalt	.052	.050
St. Louis, 50@60% asphalt	.0554	.0523
Birmingham, 55% asphalt	.0475	0475
Dallas, 45% asphalt	.0495	.0495
Dallas, 50% asphalt	.0455	.0455
Dallas, binder	.061	.061
San Francisco, binder, per ton	12.00*	12.00*

* F.o.b. Oleum, Cal. Freight to San Francisco, 80c. per ton.

E. N.-R. Prices of Construction Materials

ASPHALT—Price per ton in packages (350-lb. bbls. or 425-lb. drums) and in bulk in carload lots, f.o.b. points listed:

	Package	Bulk
New York (*Texas*)	$24.50	
Boston (*Mexican*)	23.50	$19.00
Chicago (*Texas*)	24.00	18.50
San Francisco, *f.o.b. refinery*, Oleum, Cal	18.00	12.00
Dallas (*Texas*)	27.10	21.10
Seattle, "*D*" *grade, California, f.o.b. Richmond*	19.50	13.50
Denver (*California*)	24.00	
Minneapolis, *f.o.b. Twin Cities (Stanolind)*	28.10	22.10
St. Louis (*Mexican*)	26.00	23.00
Baltimore (*Standard Oil*) (*f.o.b. refinery*)	22.50	18.50
Montreal (*Imperial*)	27.00	22.50
Atlanta (*Mexican*)	24.40	19.40
Detroit (*Mexican*)	24.00	19.00
Cincinnati (*Kentucky Rock*)	.....	11.65
Maurer, N. J. (*Bermudez*)	30.00	.....
Maurer, N. J. (*Trinidad*)	23.00	.....
Philadelphia (*Mexican*)	20.00	18.00
Kansas City, Mo. (*Texas*)	28.30	23.30
Los Angeles ("*D*" *grade, California*)	*18.00	*12.00
Birmingham (*Mexican*)	27.00	21.00
New Orleans (*Mexican*)	20.00	17.00

*F.o.b. El Segundo Refinery. Drums used in New York.

NOTE—Barrels or drums are optional in most cities. About 6 bbls. to the ton, and from 4 to 5 drums; 200 to 300 gal. to the ton.

PAVING STONE—

New York (grade I)	5-in. granite, 30 blocks per sq.yd.	$150.00 per M.
San Francisco	Basalt block 4x7x8	70.00 per M.
Chicago	about 5x8x5 dressed	3.60 per sq.yd.
	about 5x8x5 common	3.25 per sq.yd.
Boston	5-in. Granite	135.00 per M.
Atlanta	Granite	2.50 per sq.yd.
Detroit	5-in. Granite	3.00 per sq.yd.
Baltimore	Granite	2.85 per sq.yd.
Montreal	Granite	104.75 per M.
New Orleans	Granite, 4x8x4	2.75 per sq.yd.
Cincinnati	Granite	135.00 per M.
St. Louis	Granite, 4x8x4	1.65 per sq.yd.
Kansas City	Granite	3.85 per sq.yd.
Philadelphia	Granite	3.90@4.25 per sq.yd.
Minneapolis	Sandstone	2.74 per sq.yd.

FLAGGING—

New York	Bronx, 4 ft. wide	$0.24 per sq.ft.
	Manhattan, 4 ft. wide	.24 per sq.ft.
	Queens, 5 ft. wide	.26 per sq.ft.
	6x24-in. cross-walk	1.30 per lin.ft.

CURBING—*New York*: Bluestone per lin.ft., f.o.b. barge New York, 5x16 in., 90c.; *St. Louis*: Class "A" straight, delivered, 5x18 in., 90c. per lin.ft.; roundings, $1.55 per lin.ft. *Birmingham*: Limestone, 5x18-in., $1.05 per lin.ft.

WOOD BLOCK, PAVING—

	Size of Block	Treatment	Per Sq. Yd.
New York	3	16	$2.40
New York	3½	16	2.70
Boston	3½	18	2.40
Chicago	4	16	2.25
Chicago	3½	16	2.10
St. Louis	3½	16	**2.30**
St. Louis	4	16	**2.55**
Seattle	4	16	Off market
Minneapolis	3½	16	2.50
Atlanta	3½	16	2.00
New Orleans	3	16	2.20
New Orleans	3½	16	2.30
New Orleans	4	16	2.40
Dallas	4	18	3.90
Baltimore	3½	16	None used
Montreal	4	16	4.50
Detroit	3	16	1.94
Cincinnati	3½	16	2.35
Kansas City	4	16	2.50
Philadelphia	4	16	None used

Construction Materials

SAND AND GRAVEL—Price for cargo or carload lots to contractors, f.o.b., per cu.yd. Weight of sand, 1½ tons per cu.yd.; gravel, 1½ tons per cu.yd. unless otherwise specified in pounds.

	Gravel				Sand	
	1½ In.		¾ In.			
	Dec. 1	One Year Ago	Dec. 1	One Year Ago	Dec. 1	One Year Ago
New York (*alongside dock*)	$1.75	$1.75	$1.75	$1.75	$1.00	$1.00
Denver (*2,700*)	1.90	1.90	1.90	1.90	1.00	1.00
Chicago	2.00	1.85	2.00	1.85	2.00	1.65
St. Louis	1.45†	1.45†	1.45†	1.45†	1.20†	.93‡
Seattle (*3,200*) (*2,800*)	1.25	1.25	1.25	1.25	1.25	1.25
Dallas	2.38	2.38	2.38	2.38	2.00	2.00
Minneapolis (*2,800*)	1.25†	1.65†	1.25†	1.65†	1.25*	1.25*
Cincinnati	1.30†	1.30†	1.30†	1.30†	1.05†	1.05*
San Francisco (*2,800*)	1.80	1.80	1.80	1.80	1.40	1.40
Boston (*on trucks at dock*)	1.75†	1.50†	1.75†	1.50†	1.25†	1.00†
New Orleans	1.95	.....	1.95	.....	1.40	1.80
Los Angeles	2.00†	1.95†	2.00†	1.95†	1.40†	1.70†
Atlanta	.....	1.90	.....	1.90	1.75	1.60
Detroit (*2,600*)	1.70	1.45	1.60	1.35	1.35	1.10
Baltimore	1.40	1.40	1.60	1.60	.70‡†	.70‡†
Montreal	1.90†	1.25†	1.50†	1.50†	1.35†	1.25†
Birmingham (*2,700*)	1.54	2.00	1.54	2.00	1.19	1.50
Philadelphia (*2,950*)	2.25	2.10	2.25	2.10	1.65	1.50
Kansas City, Mo.	.....	.....	.....	.....	.66‡†	.70‡†
Pittsburgh	.85‡	.....	1.05‡	.....	1.25	.....

*Delivered †Per ton. ‡At pit. Note: New York in truckload lots; gravel weighs 2,800@3,000 lb. and sand, 2,700 lb.

CRUSHED STONE—Prices are for cargo or carload lots, per cu.yd., f.o.b. city. Weight 1½ tons per cu.yd., unless otherwise specified in pounds:

	1½ In.		¾ In.	
	Dec. 1	One Year Ago	Dec. 1	One Year Ago
New York (*L*)	$1.75	$1.84	$1.85	$1.94
Chicago (*L*)	2.00	1.70	2.00	1.87½
St. Louis	*1.73**	1.83*	*1.73**	1.93*
Dallas	2.40	2.40	2.38	2.83
San Francisco (*T*) (*2,400*)	1.70	1.70	1.70	1.70
Boston (*on trucks at dock*)	2.00*	1.60*	2.00*	1.60*
Minneapolis (*L*) (*2,600*)	1.25*	1.75*	1.25*	1.75*
Kansas City (*L*) (*2,450*)	2.00	2.00	2.00	2.00
Denver (*G*) (*2,700*)	2.50	2.50	2.50	2.50
Seattle (*3,000*)	2.50	3.00	2.50	3.00
Atlanta	.....	2.50	.....	2.50
Cincinnati	1.65*	1.65*	1.65*	1.65*
Los Angeles	2.00*	2.10*	2.00*	2.10*
Detroit (*L*) (*2,600*)	2.60	2.60	2.60*	2.60
Baltimore	2.50	2.50	2.55	2.55
Montreal	1.80*	1.80*	2.00*†	2.00*†
Philadelphia (*L*) (*2,590*)	2.25	2.10	2.25	2.10
Pittsburgh	2.75*	2.85	2.75*	2.85
Cleveland	2.70*	2.70*	2.70*	2.70*
Birmingham (*L*)	.85‡	2.00	1.00‡	2.00

*Per ton. †Delivered. ‡At Crusher. *L*-Limestone. *G*-Granite. *T*-Trap rock. Note: New York in truck-load lots.

CRUSHED SLAG—Price of crushed slag in carload lots, per net ton, at plant:

	1½-In.	¾-In.	Roofing	Sand
Youngstown District	$1.30	$1.40	$2.00	$1.30
Buffalo District	1.25	1.35	2.25	1.25
Birmingham, Ala.	.90	1.25	2.05	.80
Cleveland, Ohio	1.20	1.20	.....	1.30
Eastern Pa. and Northern N. J.	1.25	1.25	2.00	1.25
Western Pennsylvania	1.25	1.25	2.00	1.25
Toledo, Ohio	1.25	1.25	1.50	1.25

LIME—Warehouse prices:

	Hydrated, per Ton		Lump, per Barrel	
	Finishing	Common	Finishing	Common
New York	$19.45	$12.10	$3.50*	$2.35@2.50*
Chicago	20.00	18.00	.....	1.50†
St. Louis	23.50	17.50	.....	2.03*
Boston	**19.00**	**12.00**	3.50*	2.25@2.50*
Dallas	19.00	.....	.....	1.82†
Cincinnati	16.80	11.90	.....	11.40‡
San Francisco	27.50	**24.50**	.....	1.70†
Minneapolis	25.50	21.00	.....	1.70†
Denver	24.00	.....	.....	2.70*
Detroit	15.50	11.50	.....	12.00‡
Seattle, *paper sacks*	24.00	.....	.....	2.80*
Los Angeles	26.00	18.00	2.40†	14.00‡
Baltimore	24.25	17.85	2.55†	.....
Montreal	.....	21.00	.....	10.00‡
Atlanta	21.50	12.50	.....	1.50†
New Orleans	.....	.....	.....	2.00*
Philadelphia	23.00	15.00	.....	.....
Kansas City	19.00	17.50	2.40†	1.85†
Birmingham	22.50	16.00	2.40†	1.85†

*Per 280-lb. bbl. (net). †Per 180-lb. (net). ‡ Per ton.

NATURAL CEMENT—Price to dealers per bbl. for 500 bbl. or over, exclusive of bags:

	Dec. 1	One Year Ago
Minneapolis (Rosendale)	$2.80	$2.80
Kansas City (Ft. Scott)	1.35	1.40
Cincinnati (Utica)	1.72	1.72
Boston (Rosendale)	**2.35**	2.65
St. Louis (Carney)	*2.60*	2.35
Birmingham (Magnolia) pozzolan cement	2.40	2.40

PORTLAND CEMENT—Prices to contractors, per bbl. in carload lots, f.o.b. points listed, *without charge for bags*. Cash discount not deducted.

	Dec. 1	One Month Ago	One Year Ago
New York, del. by truck	*$2.25@$2.35	$2.35	$2.50@$2.60
New York, alongside dock to dealers	2.03	2.03	2.15
Jersey City	2.13	2.13	2.33
Boston	2.05	2.05	2.25
Chicago	2.05	2.05	2.10
Pittsburgh	2.04	2.04	2.09
Cleveland	2.24	2.24	2.29
Detroit	2.00	2.00	2.15
Indianapolis	2.19	2.19	2.29
Milwaukee	2.20	2.20	2.25
Duluth	2.04	2.04	2.09
Peoria	2.22	2.22	2.27
Cedar Rapids	2.24	2.24	2.34
Davenport	2.24	2.24	2.29
St. Louis	2.05	2.05	2.20
San Francisco	2.51	2.51	2.31
New Orleans	*2.07*	2.32	2.40
Minneapolis	2.22	2.22	2.32
Denver	2.85	2.85	2.85
Seattle	2.65	2.65	2.65
Dallas	2.05	2.05	2.05
Atlanta	2.45	2.45	2.35
Cincinnati	2.32	2.32	2.37
Los Angeles	2.56	2.56	2.50
Baltimore	2.50	2.50	2.50
Birmingham	2.40	2.40	2.40
Kansas City, Mo.	2.07	2.07	2.35
Montreal	1.41	1.41	1.41
Philadelphia	2.40	2.40	2.50
St. Paul	2.22	2.22	2.32
Toledo	2.20	2.20	2.20

NOTE—Bags 10c. each, 40c. per bbl.; 20c. each in Canada, 80c. per bbl. Current mill-prices per barrel in carload lots, without bags, to contractors:

Buffington, Ind.	$1.80	Hudson, N. Y.	$1.75
Universal, Pa.	1.80	Leeds, Ala.	1.65
Steelton, Minn.	1.85	Hannibal, Mo.	1.90
Fordwick, Va.	2.05	Lehigh Valley District	1.75
Mitchell, Ind.	1.90	Wyandotte, Mich.	1.75
Iola, Kan.	1.85	Alpena, Mich.	1.60
Mason City, Ia.	1.80	Kingsport, Tenn.	2.05
La Salle, Ill.	1.90	Clinchfield, Ga.	1.65
Richard City	$1.85		

E. N.-R. Prices of Construction Materials

TRIANGLE MESH—Price per 100 sq.ft. in carload lots at mills; from warehouse in less-than-carload lots:

PLAIN 4-INCH BY 4-INCH MESH

Style Number	Weight in Pounds per 100 sq.ft.	Pittsburgh Mill	Chicago District Mill	Warehouse: New York	St. Louis	Dallas	San Francisco
042	22	$0.99	$1.01	$1.39	$1.06	$1.13	$1.22
049	28	1.26	1.29	1.76	1.35	1.38	1.55
058	35	1.54	1.58	2.16	1.66	1.67	1.91
093	45	1.98	2.03	2.77	2.13	2.00	2.46
126	57	2.45	2.51	3.45	2.63	2.55	3.03
153	68	2.92	2.99	4.11	3.14	3.15	.....
180	178	3.35	3.43	5.70	3.60	3.47	.....
245	103	4.43	4.53	6.21	4.75	4.58	.....
287	119	5.12	5.24	7.19	5.50	5.26	6.35
336	138	5.93	6.07	8.35	6.37	6.11	.....
395	160	6.88	7.04	9.65	7.38	7.12	.....
PAVING							
036P	17	$0.76	$0.77	$1.06	$0.81	$0.76	.....
053P	24	1.07	1.09	1.50	1.14	1.07	.....
072P	31	1.35	1.38	1.90	1.45	1.39	.....
097P	40	1.74	1.78	2.45	1.87	1.90	.....
049R	24	1.07	1.09	.....	1.14	1.02	.....
067R	31	1.35	1.38	.....	1.45	1.39	.....
089R	40	1.74	1.78	.....	1.87	1.90	.....

In rolls, 48-, 52-, and 56-in. wide and in 150-, 200- and 300-ft. lengths. Galvanized is about 15% higher. Size of roll carried in New York warehouses, 48 in. wide x 150 ft. long, or 600 sq.ft.

EXPANDED METAL LATH—Prices in less-than-carload lots per 100 yd. for painted:

Weight in pounds	New York	Birmingham	Chicago	St. Louis	San Francisco	Dallas
2.2	$17.50	$19.50	$17.50	$16.50	$17.00	$24.00
2.5	18.50	21.50	18.50	17.50	19.00	26.00
3.0	21.00	24.50	21.00	20.00	22.00	29.00
3.4	22.50	27.50	22.50	21.50	24.00	31.00

BARS, CONCRETE REINFORCING—Price per 100 lb., in carload lots, f.o.b. Pittsburgh mill, and Birmingham. In other cities listed, prices are for bars out of stock at warehouse.

ROLLED FROM BILLETS

Inches	Pittsburgh	Birmingham	Warehouse: New York	Chicago	St. Louis	Dallas	San Francisco
¼ and larger	$1.80	$2.00	$3.24	$2.50	$3.15	$2.75	$2.95
⅜	1.80	2.10	3.34	2.60	3.25	2.85	3.05
½	1.80	2.20	3.44	2.70	3.35	2.95	3.15
⅝	1.80	2.40	3.64	2.90	3.55	3.10	3.35
¾	1.80	3.00	4.24	3.50	4.15	3.75	3.95

For standard classification of extras for size and cutting of steel bars, see bar card of July 15, 1923.

ROLLED FROM RAILS

	St. Louis	Dallas		St. Louis	Dallas
¼ in and larger	*$2.20*	$2.48	½	*$2.60*	$2.88
⅜	*2.30*	2.58	⅝	*3.20*	3.48
½	*2.40*	2.68	¾	.....	.....

BRICK—Contractors price, f.o.b., per M, in cargo or carload lots, is as follows:

	Common: Dec. 1	Common: One Month Ago	Common: One Year Ago	Paving: 3x8½x4-in.	Paving: 3½x8½x4-in.
New York (del.)	$16@17	$16@18	$20.40@22.40	$45.00†	$51.00†
New York (at dock)	13.00	13.00	17.00	.....	.....
Chicago	12.00	12.00	12.00	42.00	45.00
St. Louis, salmon (del.)	*14.00*	15.00	15.00	40.00	42.50
Denver, salmon	8@12	8@12	9@10	.....	.....
Dallas	13.60	13.60	14.10	35.00	.....
San Francisco	*13.00*	14.00	15.00	.....	.....
Los Angeles	10.00	10.00	11.00	(not used)	
Boston (del.)	18.00	18.00	19.00	45.00	50.00
Minneapolis (del.)	13.75	13.75	13.75	.....	.....
Kansas City	14.00	14.00	14.00	(no market)	
Seattle	14.00	14.00	15.00	.....	55.00
Cincinnati	15.50	15.50	15.50	40.00	45.00
Montreal (del.)	20.25	20.25	20.25	100.00‡	.....
Detroit (del.)	15.50	15.50	16.00	35.25	38.50
Baltimore	18.00	18.00	18.00	40.00	45.00
Atlanta	11.50	11.50	12.00	40.00	.....
New Orleans	13.00	13.00	15.00	60.00	75.00
Birmingham	14.50	14.50	14.50	40.00	45.00
Philadelphia	18.00	18.00	18.00	40.00	50.00
Pittsburgh (del.)	17.00	17.00	16.00	.....	.....
Cleveland	14@16	14@16	*12@14	.....	.....

* By truck. † In cars. ‡ Imported.

HOLLOW TILE—Price per block in carload lots, f.o.b., to contractors, for hollow building tile.

	New York: Dec. 1 on Trucks*†	New York: One Year Ago	Chicago	Philadelphia	St. Louis	San Francisco†	Perth Amboy N. J., Factory*
4x12x12	$0.0966	$0.1027	$0.076	$0.105	$0.068	$0.108	.....
6x12x12	.145	.1541	.104	.....	.09	.156	.....
8x12x12	.1812	.1926	.142	.21	.126	.244	.....
10x12x12	.....	.....	.182	.....	.158	.....	$0.2432
12x12x12	.....	.....	.202	.32	.186	.....	.3011

*5 per cent off for cash. †Partition tile.

	4x12x12	8x12x12	12x12x12
Boston	$0.08	$0.14	*$0.235*
Minneapolis	.072	.125	.225
Cincinnati	.064	.1295	.1726
Kansas City	.088	.158	.242
Denver	.085	.155	.22
Seattle	.10	.18	.26
Los Angeles	.085	.172	.285
New Orleans	.0808	.1516	.2232
Detroit	.068	.1326	.1853
Montreal	.10	.....	.....
Baltimore	.124	.268	.....
Atlanta	.068	.125	.....
Dallas	.103	.19	.31
Birmingham	.11	.124	.255
Pittsburgh	.069	.128	.179
Cleveland	.06	.12	.....

STRUCTURAL MATERIAL—Following are base prices per 100 lb. in carload lots, f.o.b. Pittsburgh mill, and Birmingham. At other cities listed, quotations apply on less-than-carload lots from warehouses:

	Pittsburgh	Birmingham	Warehouse: New York	Dallas	St. Louis	Chicago	San Francisco
Beams, 3 to 15 in.	$1.80	$1.90@$2.00	$3.34	$4.00	$3.25	$3.10	$3.00
Channels, 3 to 15 in.	1.80	1.90@2.00	3.34	4.00	3.25	3.10	3.00
Angles, 3 to 6 in., ¼ in. thick	1.80	1.90@2.00	3.34	4.00	3.25	3.10	3.00
Tees, 3 in. and larger	1.80	1.90@2.00	3.34	4.00	3.35	3.10	3.00
Plates, ¼ in thick and heavier	1.80	1.90@2.00	3.34	4.00	3.25	3.10	3.00

RIVETS—The following quotations are per 100 lb.:

ROUND-HEAD STRUCTURAL

	Pittsburgh Mill	New York: Dec. 1	New York: One Yr. Ago	Warehouse: Chicago	St. Louis	San Francisco	Dallas
½ in.	$2.75@$3.00	$5.00	$4.20	$3.60	$3.75	$5.75	$4.75
CONE-HEAD BOILER							
½ in.	$3.25	$5.00	$4.40	$3.60	$3.90	$5.75	$5.00
⅝ and ¾	3.40	5.15	4.55	3.70	4.10	5.90	5.15
⅞ and 1	3.55	5.40	4.80	3.95	4.15	6.10	5.50

NAILS—The following quotations are per 100 lb. keg from warehouse:

	Pittsburgh Mill	Birmingham	Chicago	San Francisco	Dallas	St. Louis	Montreal
Wire	$2.55	$2.85	$2.95	$3.25	$4.25	$2.83	$4.95
Cut	2.80	2.90	.....	4.90	5.00	*2.88*	5.00

SHIP SPIKES—Current prices per 100 lb.:

In	San Francisco: Galv.	San Francisco: Black	Seattle Black
½	$7.30	$5.55	$7.75
⅝	6.85	5.10	5.65
¾	6.70	4.95	5.50

Pittsburgh base in lots of 200 kegs or more, $3.30.

PREPARED ROOFINGS—Slate-surfaced roofing in rolls weighing 85 to 90 lb. costs $1.93¾ per square to contractors in carload lots f.o.b. New York.

Single shingles, slate finish, cost $5.62½ per square (sufficient to cover 100 sq.ft.) in carload lots, f.o.b. New York. Strip shingles (4 in 1) f.o.b. New York, in carload lots to contractors, $4.27½ per square for the hexagonal shape, with Underwriters' label.

ROOFING MATERIALS—Prices f.o.b. New York, to contractors in carload lots:

Tarred felt per 100 lb	$2.94½
Asphalt coating, per gal	.31½
Asphalt felt, per 100 lb	3.09

WINDOW GLASS—United inches, 25, bracket size 6x8 to 10x15, single thickness "AA," 83 per cent; "A," 88 per cent; "B," 89 per cent. Double thickness "AA," 83 per cent; "A," 88 per cent; "B," 89 per cent discount from jobbers list at New York warehouses.

SHEETS—Quotations are per 100 lb. in various cities from warehouse also the base quotations at mill:

Blue Annealed	Pittsburgh Large Mill Lots	St. Louis	Chicago	San Francisco	New York
No. 10	$2.10@2.15	$3.60	$3.50	$3.75	$3.89
No. 12	2.15@2.20	3.65	3.55	3.80	3.94
No. 14	2.20@2.25	3.70	3.60	3.85	3.99
No. 16	2.30@2.35	3.80	3.70	3.95	4.09
Black					
Nos. 18 to 20	$2.70	4.25	3.75	4.60	4.00
No. 22	2.85	4.40	3.90	4.75	4.15
No. 24	2.90	4.45	3.95	4.80	4.20
No. 26	3.00	4.55	4.05	4.90	4.30
No. 28	3.15	4.70	4.20	5.05	4.45
Galvanized					
No. 10	*2.95@3.05*	4.55	4.10	4.65	4.25
Nos. 12 to 14	*3.05@3.15*	4.65	4.20	4.75	4.35
No. 16	*3.15@3.25*	4.75	4.30	4.85	4.45
No. 18	*3.30@3.40*	4.90	4.45	5.00	4.60
No. 20	*3.45@3.55*	5.05	4.60	5.15	4.75
No. 22	*3.50@3.60*	5.10	4.65	5.20	4.80
No. 24	*3.65@3.75*	5.25	4.80	5.35	4.95
No. 26	*3.90@4.00*	5.50	5.05	5.60	5.20
No. 28	*4.15@4.25*	5.75	5.30	5.85	5.45

For galvanized corrugated sheets add 15c., all gages.

LINSEED OIL—These prices are per 7½-lb. gallon for raw oil:

	New York: Dec. 1	New York: One Year Ago	Chicago: Dec. 1	Chicago: One Year Ago
Raw in barrels (5 bbl. lots)	$0.79½	$0.86½	$0.83	$0.84

E. N.-R. Prices of Construction Materials

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Dec. 1	1 Yr. Ago	Dec. 1	1 Yr. Ago
Red	$13.75	$15.25	$15.25	$16.75
White	13.75	15.25	13.75	15.25

Lumber

Prices wholesale, per M. ft. b.m., in carload lots, f.o.b.

San Francisco—Prices of rough Douglas fir No. 1 common, in carload lots to contractors at yards.

	6-8 and 12 Ft.	10-16-18 and 20 Ft.	22 and 24 Ft.	25 to 32 Ft.
3x3 and 4	$26.00	$27.00	$28.00	$31.00
3x6 and 8	26.00	27.00	28.00	31.00
4x4-6 and 8	26.00	27.00	28.00	31.00
3x10 and 12	26.00	27.00	28.00	31.00
3x14	30.00	30.00	32.00	34.00
4x10 and 12	26.00	27.00	28.00	31.00
4x14	30.00	30.00	32.00	34.00

	24 Ft. and Under	25 to 32 Ft.	33 to 40 Ft.
6x10	$28.00	$30.00	$32.00
6x14	34.00	36.00	38.00
8x10	28.00	30.00	32.00
8x14	34.00	36.00	38.00

New York and Chicago—Wholesale prices to dealers:

	New York		Chicago	
	20 Ft. and Under L.L.Y.P.	22-24 Ft. L.L.Y.P.	20 Ft. and Under No. 1 L.L.Y.P.	Up to 32 Ft. No. 1 Douglas Fir
3x4 to 8x8	$41.00@43.00	$42.00@44.00	$37.00	$39.50
3x10 to 10x10	48.00@50.00	49.00@51.00	45.00	39.50
3x12 to 12x12	55.00@57.00	56.00@58.00	55.00	39.50
3x14 to 14x14	63.00@65.00	64.00@66.00	.....	39.50
3x16 to 16x16	75.00@77.00	76.00@78.00	....	40.50

New York—Prices are for long-leaf yellow pine timbers (rough) to dealers, alongside dock. Price to contractors, delivered by trucks from lighters to job, $5@$10 additional. Short leaf pine costs $3 per M. ft. less.

Over 24 ft.—Add $1 for each additional 2 ft. in length up to 32 ft. and $1 for each additional foot from 32 to 36 ft.

Other Cities—On cars or at dock:

	8x8-In. x 20 Ft. and Under				3x12 to 12x12-In. 20 Ft. and Under	
	P.	Fir*	Hemlock	Spruce	P.	Fir*
Boston	$48.00	$47.50	$49.00	$52.00	$57.50	$57.00
Seattle	.....	24.00	.....	.....	.....	24.00
New Orleans	45.00	.....	.....	.....	.....	.....
Baltimore	35.00	49.25	53.00	60.00	.....	*49.25*
Cincinnati	50.00	.....	.....	.....	65.00	.....
Montreal	*50.00*	55.00	.....	.....	60.00	50@55
Los Angeles	.....	32.00	.....	32.00	.....	32.00
Denver	.....	*32.75*	*32.75*	*32.75*	*33.75*	*33.75*
Minneapolis	42.50	36.75	34.50	.....	47.00	36.75@38.75
Atlanta	31.00	.....	.....	.....	34.00	.....
Dallas	56.00	.....	.....	.....	56.00	.....
Kansas City, Mo.	40.50	42.75	.....	.....	54.50	42.75
Birmingham	32.00	.....	.....	.....	34.00	.....
Philadelphia	48.00	35.00	40.00	45.00	60.00	35.00
Detroit	*42.00*	*40.50*	.....	.....	56.00	*40.50*
St. Louis	40.00	.....	.....	.....	*51.50*	.....

	1-In. Rough, 10 In. x 16 Ft. and Under			2-In. T. and Gr. 10 In. x 16 Ft.	
	P.	Fir*	Hemlock	P.	Fir*
Boston	$43.50	$43.00	$44.50	$48.50	$48.00
Seattle	.....	22.00	.....	.....	23.50
New Orleans	30.00	.....	.....	40.00	.....
Baltimore	55.00	44.00	44.00	34.00	49.50
Cincinnati	42.50	.....	.....	40.00	.....
Montreal	45.00	55.00	40.00	65.00	50.00
Los Angeles	.....	24.50	.....	.....	36.00
Denver	.....	32.75	33.25	.....	*31.75*
Minneapolis	40.50	36.25	34.75	35.50	35.00
Atlanta	22.50	.....	.....	28.00	.....
Dallas	52.25	.....	.....	56.00	.....
Kansas City, Mo.	50.25	*40.75*	.....	*37.25*	*37.00*
Birmingham	27.00	.....	.....	45.00	.....
Philadelphia	32.00	35.00	37.00	50.00	35.00
Detroit	40.50	37.00	.....	30.50	41.25
St. Louis	39.00	.....	.....	*27.50*	.....

*Douglas fir.

PILES—Prices per lineal foot, pine piles with bark on, f.o.b. New York:

Diameters	Points	Length	Barge	Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.14½	$0.18½
12 in.—2 ft. from butt	6 in.	50 to 59 ft.	.19	.23½
12 in.—2 ft. from butt	6 in.	60 to 69 ft.	.21½	.25½
14 in.—2 ft. from butt	6 in.	50 to 69 ft.	.25½	.34
14 in.—2 ft. from butt	6 in.	70 to 79 ft.	.27½	.36½
14 in. —2 ft. from butt	5 in.	80 to 89 ft.	.35	.41

Miscellaneous

STEEL SHEETPILING—The following price is base per 100 lb. f.o.b. Pittsburgh, with a comparison of a month and a year ago:

Dec. 1	One Month Ago	One Year Ago
$2.20@$2.25	$2.20@$2.25	$2.25@$2.30

CONCRETE BLOCKS—Standard 8x8x16-in., delivered to job, each:

Denver	$0.22	St. Louis	$0.20
Detroit	.16	Boston	18@.20
New Orleans	....	Minneapolis	.14*
Brooklyn and Queens	18@.20	Philadelphia	18@.20
Pittsburgh	.18	*F.o.b.	

WIRE ROPE—Discounts from list price on regular grades of bright and galvanized are as follows:

	Eastern Territory New York and East of Missouri River
Plow steel round strand rope	35%
Special steel round strand rope	30%
Cast steel round strand rope	20%
Round strand iron and iron tiller	5%
Galvanized steel rigging and guy rope	7½%
Galvanized iron rigging and guy rope (*add to list*)	12½%

California, Oregon, Nevada and Washington: Discount 5 points less than discount for Eastern territory.

Wyoming, New Mexico and Colorado: Discount 5 points less than discount for Eastern territory.

Arizona: Discount 10 points less than discount for Eastern territory.

Montana, Idaho and Utah: Discount 10 points less than discount for Eastern territory.

North Dakota, Nebraska, Kansas, Oklahoma and Texas: Discount 5 points less than discount for Eastern territory.

MANILA ROPE—For rope smaller than ¼-in. the price is ½ to 2c. extra; while for quantities amounting to less than 600 ft., there is an extra charge of 1c. The number of feet per pound for the various sizes is as follows: ⅛-in., 8 ft.; ¼-in., 6; ⅜-in., 4½; ½-in., 3½; ⅝-in., 2 ft. 10 in.; ¾-in., 2 ft. 4 in. Following are prices per pound for ⅛-in. and larger, in 1200-ft. coils:

Boston	$0.25	New Orleans	$0.23½
New York	.26	Los Angeles	.25
Chicago	.23½	Seattle	.23
Minneapolis	.25½	St. Louis	.23
San Francisco	.23	Montreal	.17
Atlanta	.22	Detroit	.24½
Denver	.25½@.26½	Baltimore	.26
Cincinnati	.21	Kansas City	.25½
Dallas	.31	Birmingham	.26@.27
Philadelphia	.25		

EXPLOSIVES—Price per pound for dynamite in small lots:

	Gelatin 40%	Gelatin 60%
New York	$0.265*	$0.2875*
Boston	.235	.265
Kansas City	.205	.225
Seattle	.165	.19
Chicago	.195†	.2175†
Minneapolis	.1917	.2123
St. Louis	.22	.24½
Denver	.2025	.2275
Dallas	.225	.306
Los Angeles	.1875	.2225
Atlanta	.245	.255
Baltimore	.22	.23
Cincinnati	.22	.245
Montreal	.1675	.1895
Birmingham	.22	.24
New Orleans	.235	.26
San Francisco	.1625	.1925
Philadelphia	.215	.24

*Special gelatin in case lots. †Quantities above 500. lb., and less than a ton.

CHEMICALS—Water and sewage treatment chemicals, round lots at New York:

Sulphate of aluminum, in bags, per 100 lb	$2.00@$2.10
Sulphate of copper, in bbl., per 100 lb	5.00@5.10
Soda ash, 58%, in bags, per 100 lb	*1.35@1.45*
Chlorine, liquid, cylinders, per lb	.05½@.08
Hypochlorite of lime (bleaching powder) in drums, per 100 lb	2.00@2.10*

*F. o. b. works.

FREIGHT RATES—On finished steel products in the Pittsburgh district, including plates, structural shapes, merchant steel, bars, pipe fittings, plain and galvanized wire nails, rivets, spikes, bolts, flat sheets (except planished), chains, etc., the following freight rates are effective in cents per 100 lb., in carloads of 36,000 lb. or 18 tons:

Atlanta	$0.58	Detroit	$0.29
Baltimore	.31	Kansas City	.735
Birmingham	.58	New Orleans	.67
Boston	.365	New York	.34
Buffalo	.265	Pacific Coast (all rail)	1.15*
Chicago	.34	Philadelphia	.32
Cincinnati	.29	St. Louis	.43
Cleveland	.19	St. Paul	.60
Denver	1.15*		

* Minimum carload, 50,000 lb., structural steel only; 80,000 lb., for other iron or steel products.